CLIMATE AND AIR QUALITY ASSESSMENT OF THE PROPOSED NORTHERN TIER PIPELINE IN MONTANA

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OF THE
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IN MONTANA

DRAFT FINAL REPORT

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PREFACE

This technical report, prepared for the Department of Natural Resources and Conservation (DNRC) of the State of Montana (David Janis--Project Manager) addresses the climate and air quality assessment of the proposed Northern Tier Pipeline and DNRC alternate routes in Montana. The work was performed by the Environmental Division of the Montana Energy and MHD Research and Development Institute (MERDI) under the supervision of Ed Kukay, Program Manager. The assessments were coordinated by Victor Garrett and Gordon Huddleston and the report was written by Jeff Chaffee and Steve Heck.

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NORTHERN TIER CLIMATE AND AIR QUALITY ASSESSMENT

Technical Report

I. INTRODUCTION

To evaluate the impact of the Northern Tier pipeline in Montana, numerous aspects of the natural, physical, and social environments must be assessed. The Montana Energy and MHD Research and Development Institute (MERDI) has contracted with the Montana Department of Natural Resources and Conservation (DNRC) to assess the pipeline's impact on the state's climate and air quality; other contractors are addressing impacts on additional portions of the physical, natural, and social environments. The studies are being conducted to determine the most environmentally acceptable route for the pipeline in Montana.

To assist in delineating the best route for the crude oil transportation system, MERDI has assessed the climate and air quality along proposed and alternate pipeline routes and outlined possible impacts. These parameters are described in this report. This information can be used as input for an environmental impact statement (EIS) on the Northern Tier pipeline corridors in Montana.

II. METHODOLOGY

To assess the climate and air quality along the proposed and alternate Northern Tier corridors in Montana, the following methodology was used by MERDI:

- Available data were located and obtained from various state and federal agencies; the Montana Air Quality Bureau was consulted for the air quality information, and the climatic data were obtained from the National Weather Service and others.

- The climate/air quality information was summarized and displayed on transparent overlay maps as dispersion potential and air quality ratings (Tables 1 and 2 show the criteria used to generate the air quality and dispersion potential ratings).

- The overlay maps and tables of supporting data were supplied to DNRC for use in corridor comparison.

- Alternate centerlines, generated from corridor comparison, were evaluated in preparation for a final pipeline route recommendation.

- This technical report was written to present and analyze the collected air quality/climatology information and to identify potential pipeline impacts on these resources.

Table 1.--Northern Tier Air Quality Rating Criteria

Concerns and Criteria	Units	Categories: Poor	Fair	Good
A. Air Quality Criteria				
1. Distance from a PSD Class I Area	KM	0-48.3	48.3-96.5	> 96.5
2. Nonattainment Status for 1 or more pollutants	1 or more pollutants	Yes	--	No
3. Total Suspended Particulate				
a. Annual Geo. Mean	$\mu g/m^3$	>60	30-60	<30
b. Max. 24-hour Average	No. Occurrences >150 $\mu g/m^3$	> 3	1-3	0
4. Sulfur Dioxide				
a. Annual Arith. Mean	ppm	>0.02	0.005-0.02	<0.005
b. Max. 24-hour Average	No. Occurrences > 0.10 ppm	>3	1-3	0
5. Nitrogen Oxides (Annual)	ppm	>0.05	0.010-0.050	<0.010
6. Carbon Monoxide				
a. 8-hour Average	No. Occurrences >9.0 ppm	>3	1-3	0
b. 1-hour Average	No. Occurrences >35.0 ppm	>3	1-3	0
7. Other Pollutants as Appropriate				
a. Ozone (O_3) (1 hour)	No. Occurrences >0.08 ppm	>3	1-3	0
b. Total Hydrocarbons (Annual)	ppm	>2.0	1.0-2.0	<1.0

I. For Each Major Criteria:

1 = Poor	< 2 = Poor
2 = Fair	2-2.5 = Fair
3 = Good	>2.5 = Good

(Right column: Criteria Average)

II. Overall Rating of Corridors:

Poor = two or more criteria have an average rating <2.
Fair = one or more categories rated <2.5, max. of one criteria <2.
Good = no criteria rated <2.5.

III. In the absence of data, best estimates will be made for fair and good categories; most poor areas are assumed to have monitoring data.

All towns with a population near or exceeding 5,000 will be identified and rated as fair unless data exists to verify a good or poor rating.

Table 2.--Northern Tier Meteorological Rating Criteria

		UNITS	POOR	FAIR	GOOD	WEIGHTING FACTORS
I.	Rainfall Frequency					
	a. Days with .01" or more	Days	< 90	90-110	> 110	1
	b. Days with .10" or more	Days	< 40	40-50	> 50	1
II.	Wind Speed					
	a. Average wind speed	Knots	< 7	7-9.5	> 9.5	3
	b. Percent of winds below 7 knots	%	>50	30-50	<30	3
III.	Mixing Height					
	a. Morning mixing height	Meters	< 350	350-450	>450	1
	b. Afternoon mixing height	Meters	<1800	1800-2000	>2000	1
	Inversion Frequency					
	a. Percent of total hours with inversion	%	>40	36-40	<36	2
	b. Percent of days on which at least 1 hour of inversion conditions occur.	%	>79	73-79	<73	2

I. For Individual Criteria:

1 = Good

2 = Fair

3 = Poor

II. Areas are given an overall rating based on a weighted average including all criteria according to the following values:

<1.8 = Good

1.8 to 2.25 = Fair

>2.25 = Poor

III. DESCRIPTION OF THE EXISTING ENVIRONMENT

Two aspects of the air environment are considered in this study: 1) climate and dispersion potential and 2) the existing air quality. Impacts of potential emissions from the proposed pipeline will be greatly influenced by the existing climate and dispersion potential. The existing air quality determines, to a large degree, the acceptability of potential emissions.

A. Climate and Dispersion Potential

The climate along the proposed and alternate pipeline routes varies from a modified Pacific type near the western corner to a decidedly Continental type in the eastern third of the state. The terrain in Montana is diverse, varying from rugged mountainous areas in the west and southwest to Great Plains country in the northeast. The Continental Divide runs roughly north-northwest to south-southeast in the western portion of the state. The climate of the state is influenced greatly by the varying terrain, with three major identifiable climatic types:

- Western Montana has a modified Pacific Coast climate; Pacific air masses exert a strong influence eastward to the Continental Divide;
- East of the divide, for a distance of approximately 250 kilometers (150 miles) through Central Montana, lies a modified continental climatic zone--termed "modified" due to the large number of winter days during which mild chinook winds blow down the east slope of the Rockies; and
- Eastern Montana has a markedly continental type climate, which is similar to that of the Dakotas.

The dispersal or concentration of pollutants depends partly on meteorological factors, and to some extent on topography. These conditions help determine to what degree pollutants will present a problem in the environment. One important consideration is wind speed. High winds

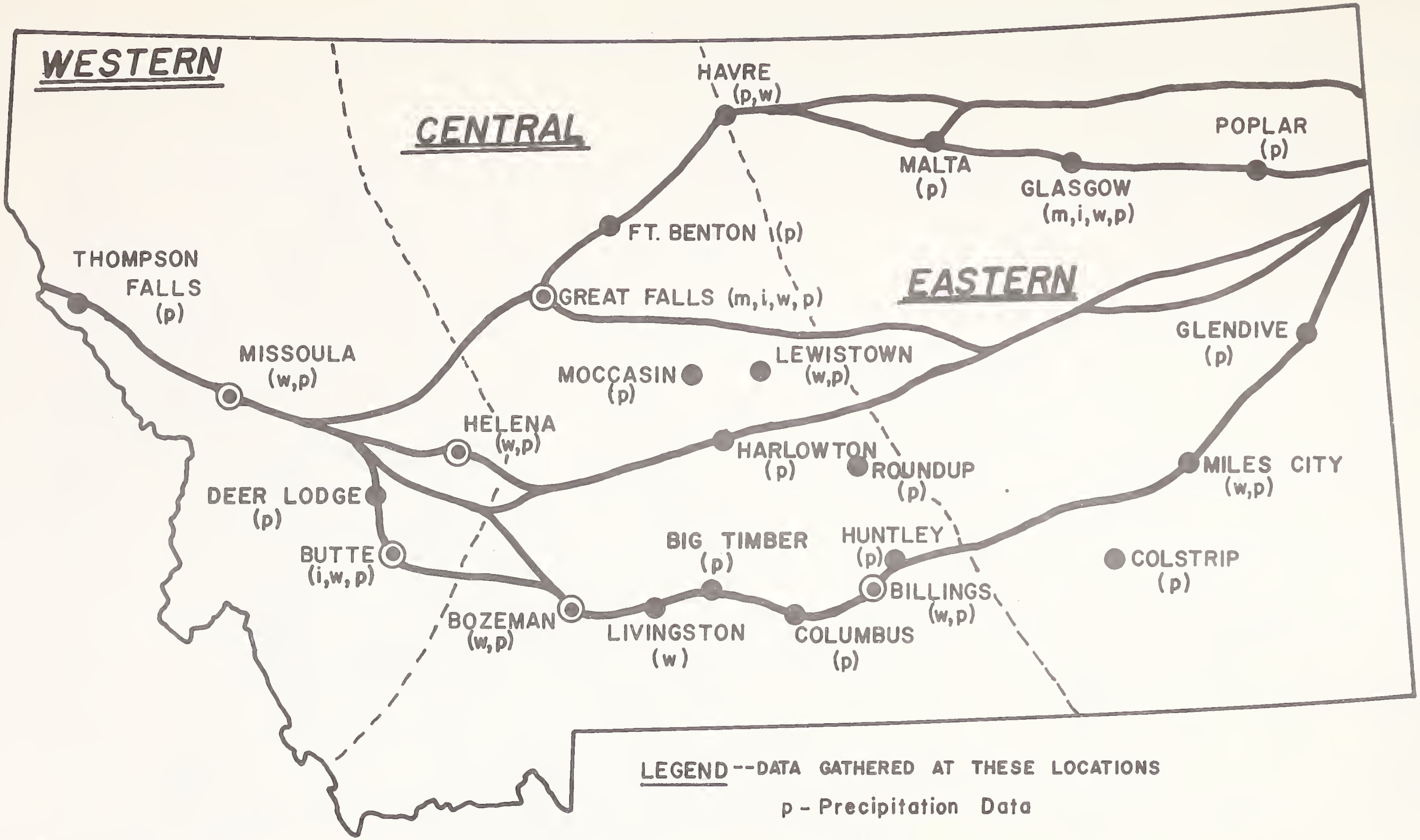
usually disperse pollutants to lower concentrations, while long periods of low winds can permit the build-up of pollutants. Another factor is atmospheric stability. When the atmosphere is neutral or unstable, ventilation is good and pollutants tend to disperse readily. During stable periods, however, pollutants tend to stay close to the ground and air quality problems can result. This is particularly true during inversion conditions. Another meteorological factor related to stability is mixing height--the vertical depth of the atmosphere that is neutral or unstable measured from the ground up. If the mixing height is sufficient, pollutants can disperse in a large area, resulting in low concentrations. High pollutant concentrations can occur with low mixing heights due to the restricted area in which pollutants disperse. A lesser consideration is precipitation frequency; during precipitation episodes, washout of pollutants generally occurs, contributing to lower overall pollutant concentrations.

1. Climate of Western Montana

The proposed and alternate pipeline corridors extend southeastward from Thompson Falls through the Western climatic region (Figure 1). This is the area of the state most strongly influenced by Pacific air masses. The terrain in this section of the state is very mountainous; the mountain-valley configuration contributes to large climatic variations within short distances.

a. Temperature

As a result of the strong influence of Pacific air masses, temperatures in this section of the state are less variable on an annual basis than in other parts of Montana. Figures 2 through 5 show mean maximum and minimum temperatures for January and July for Montana. The January maps illustrate the effect of the Continental Divide in limiting the westward



LEGEND--DATA GATHERED AT THESE LOCATIONS

p - Precipitation Data

w - Wind Data

m - Mixing Height Data

i - Inversion Data

Montana Energy & MHD Research & Development Institute, Inc. Butte, Montana
Drawn By J.E.F./W.M.
22 Feb. 1979
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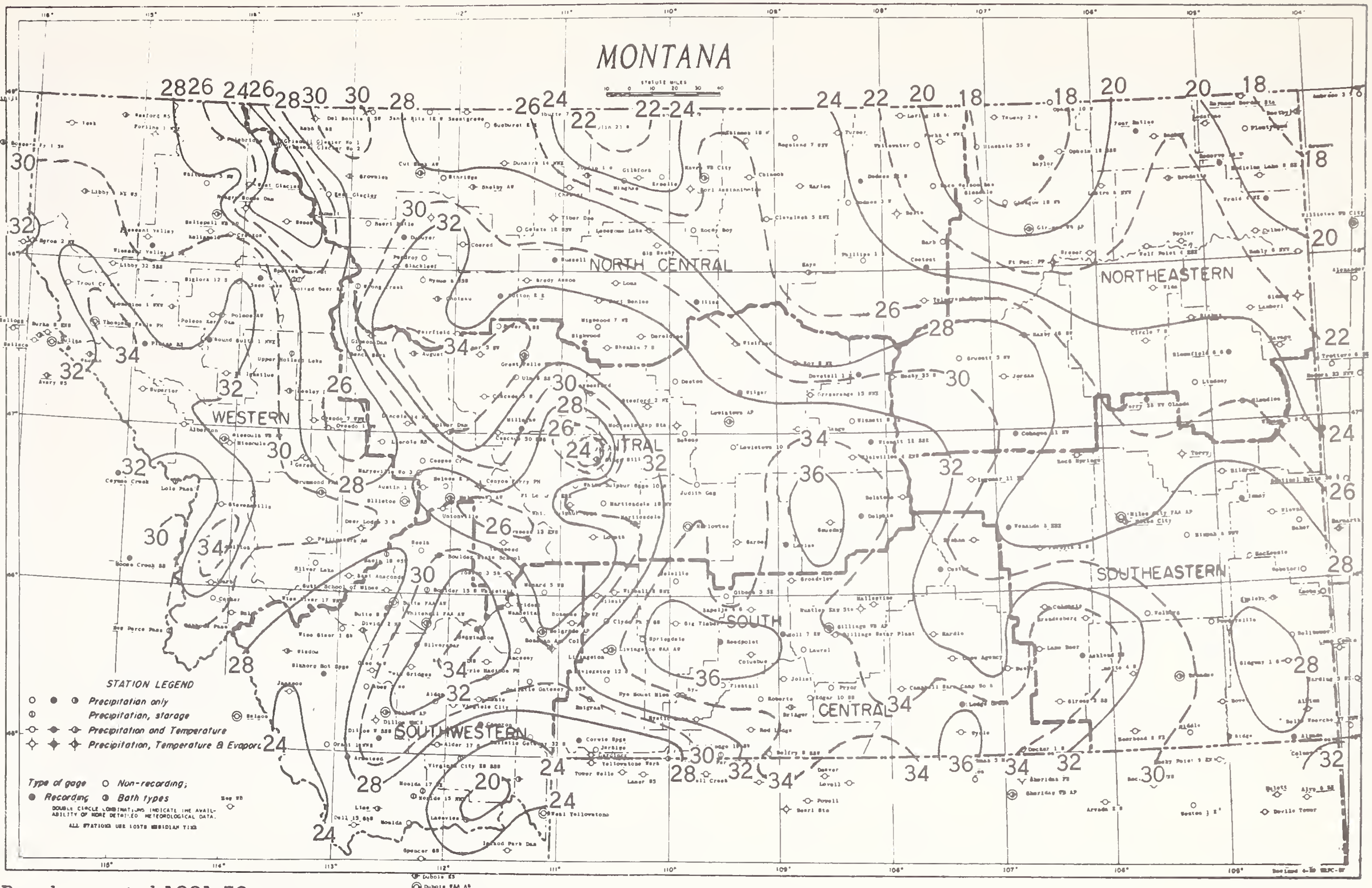
Figure 1. METEOROLOGY DATA ALONG NORTHERN TIER CORRIDORS

Mean Maximum Temperature (°F.), January



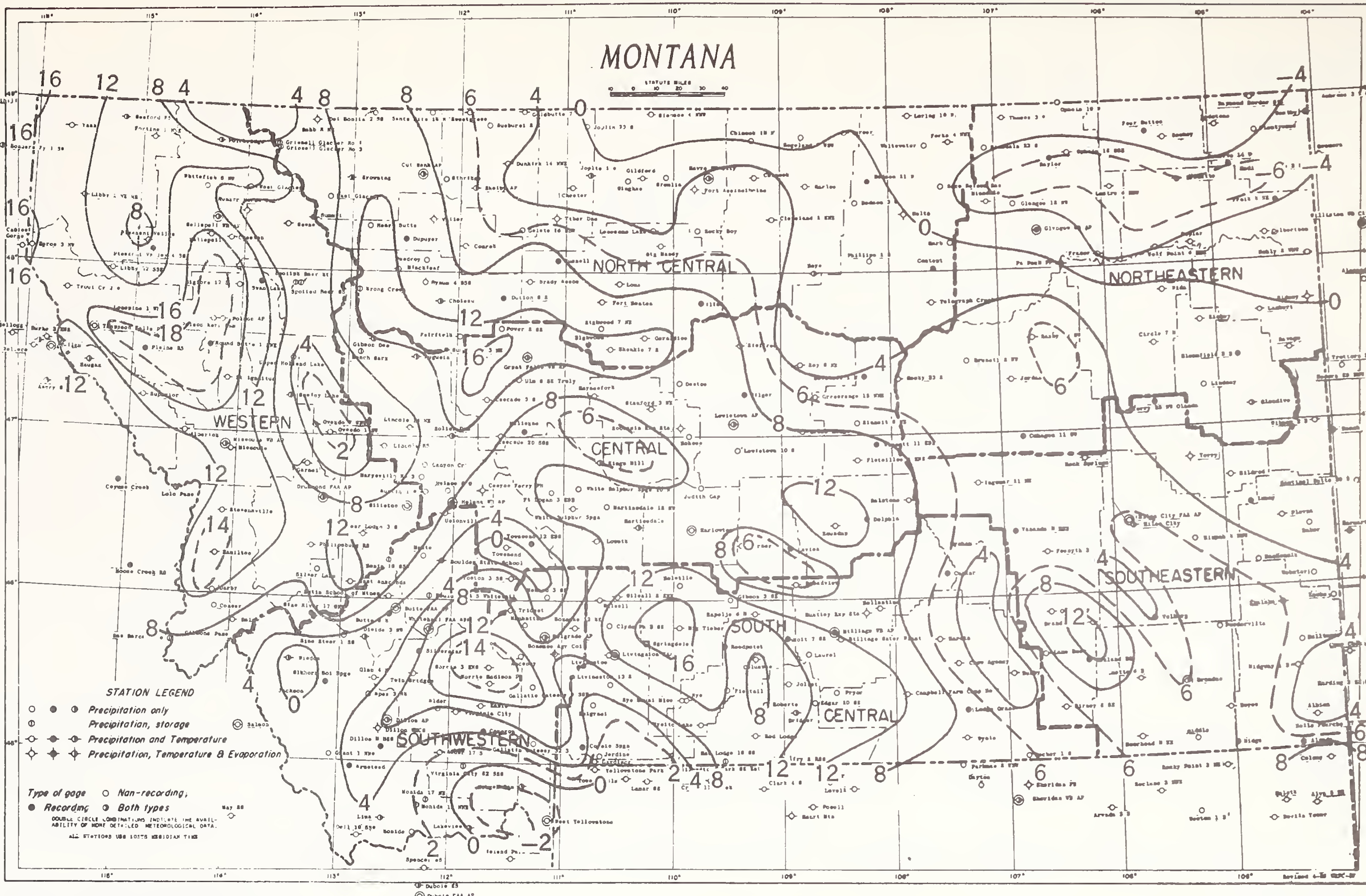
Based on period 1931-52

USCOMM-WB-ASHEVILLE

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.

Figure 2.--Mean Maximum Temperature (^{O}F), January
Source: U.S. Department of Commerce, 1971.

Mean Minimum Temperature (°F.), January

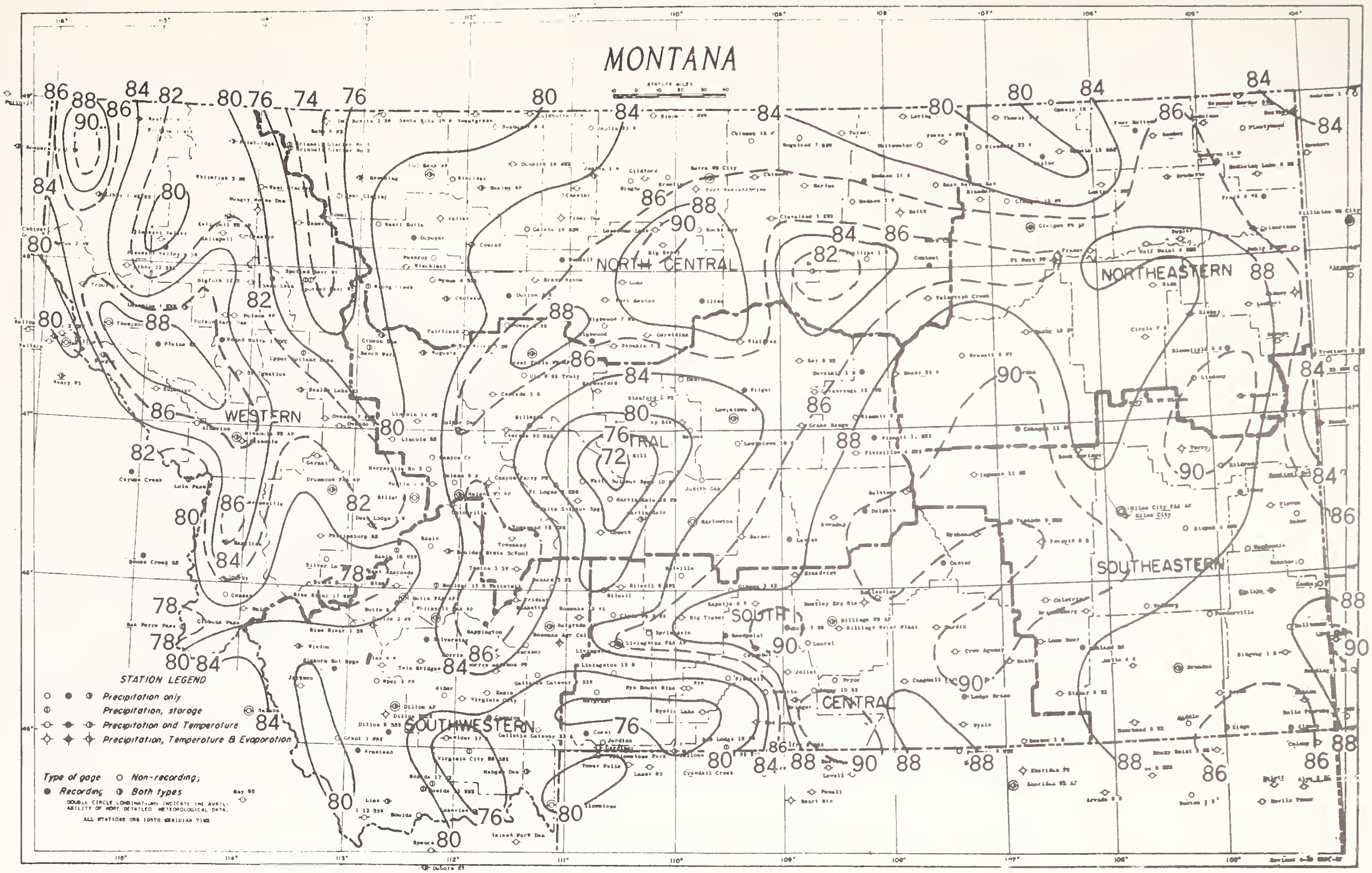


Based on period 1931-52

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.

Figure 3.--Mean Minimum Temperature (^{O}F), January
Source: U.S. Department of Commerce, 1971.

Mean Maximum Temperature (°F.), July

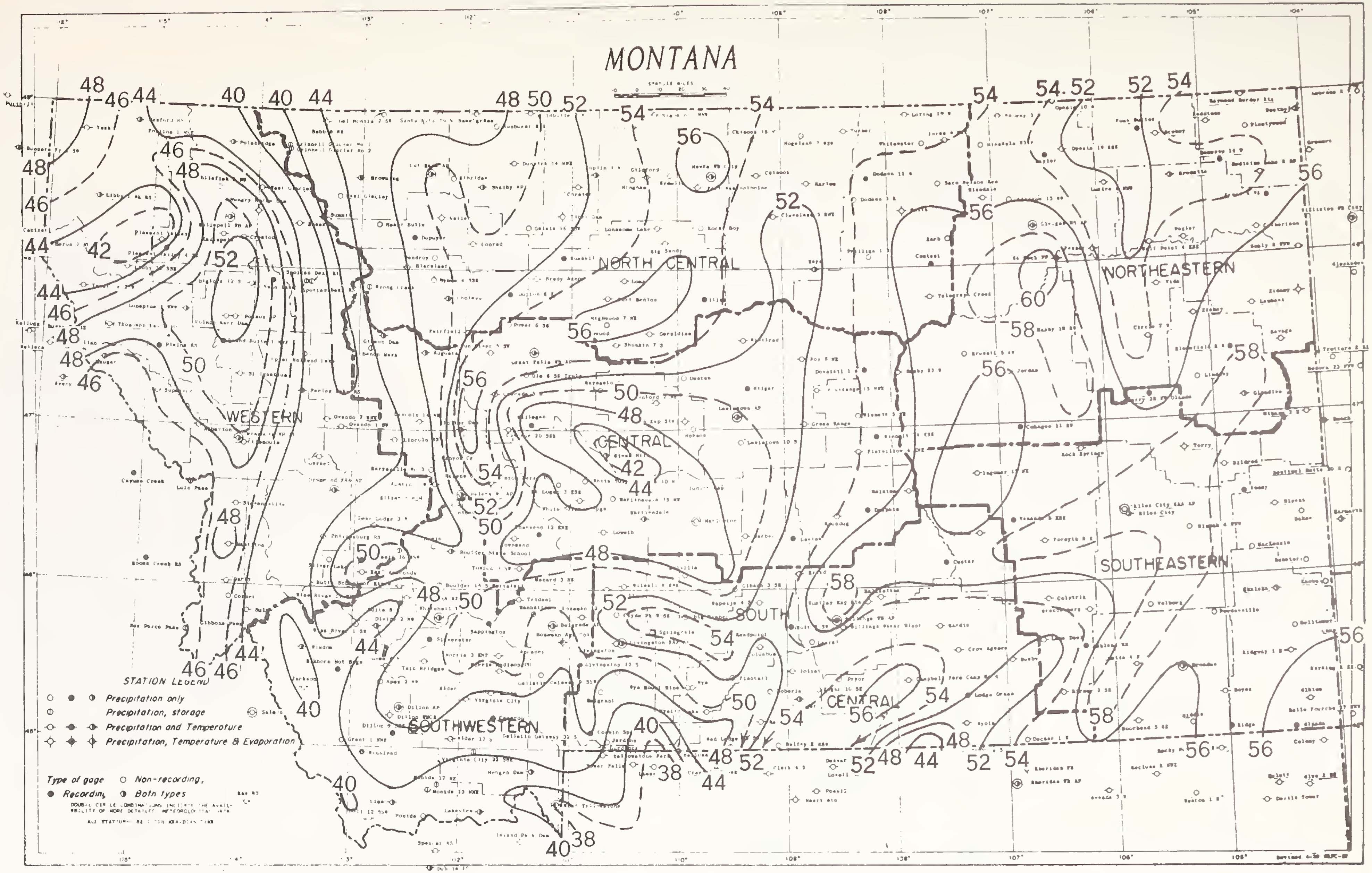


Based on period 1931-52

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.

Figure 4.--Mean Maximum Temperature (^{0}F), July
Source: U.S. Department of Commerce, 1971.

Mean Minimum Temperature (°F.), July



Based on period 1931-52

USCOMM-WB-ASHEVILLE

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.

Figure 5.--Mean Minimum Temperature (^{O}F), July
Source: U.S. Department of Commerce, 1971.

penetration of the arctic air masses that affect eastern Montana. A general decrease in temperature is noted in going from north to south, caused by the much higher elevation of the southern part of this region. January maximums range from 25^{o} to $35^{o}F$, with minimums between 10^{o} and $20^{o}F$, except for near $0^{o}F$ averages in some of the higher valleys. The effects of Pacific air masses are much weaker in the summer, with normally high diurnal temperature variations. Average maximum temperatures are between 80^{o} and $90^{o}F$, and minimum temperatures average between 40^{o} and $50^{o}F$, giving many areas an average diurnal range of $40^{o}F$ or more.

The average growing season varies greatly because of the large variations in topography and elevation, as shown in Table 3. The average growing season ranges from 39 days at Ovando to 128 days at Missoula, and usually varies inversely with elevation.

b. Precipitation, Evaporation, and Humidity

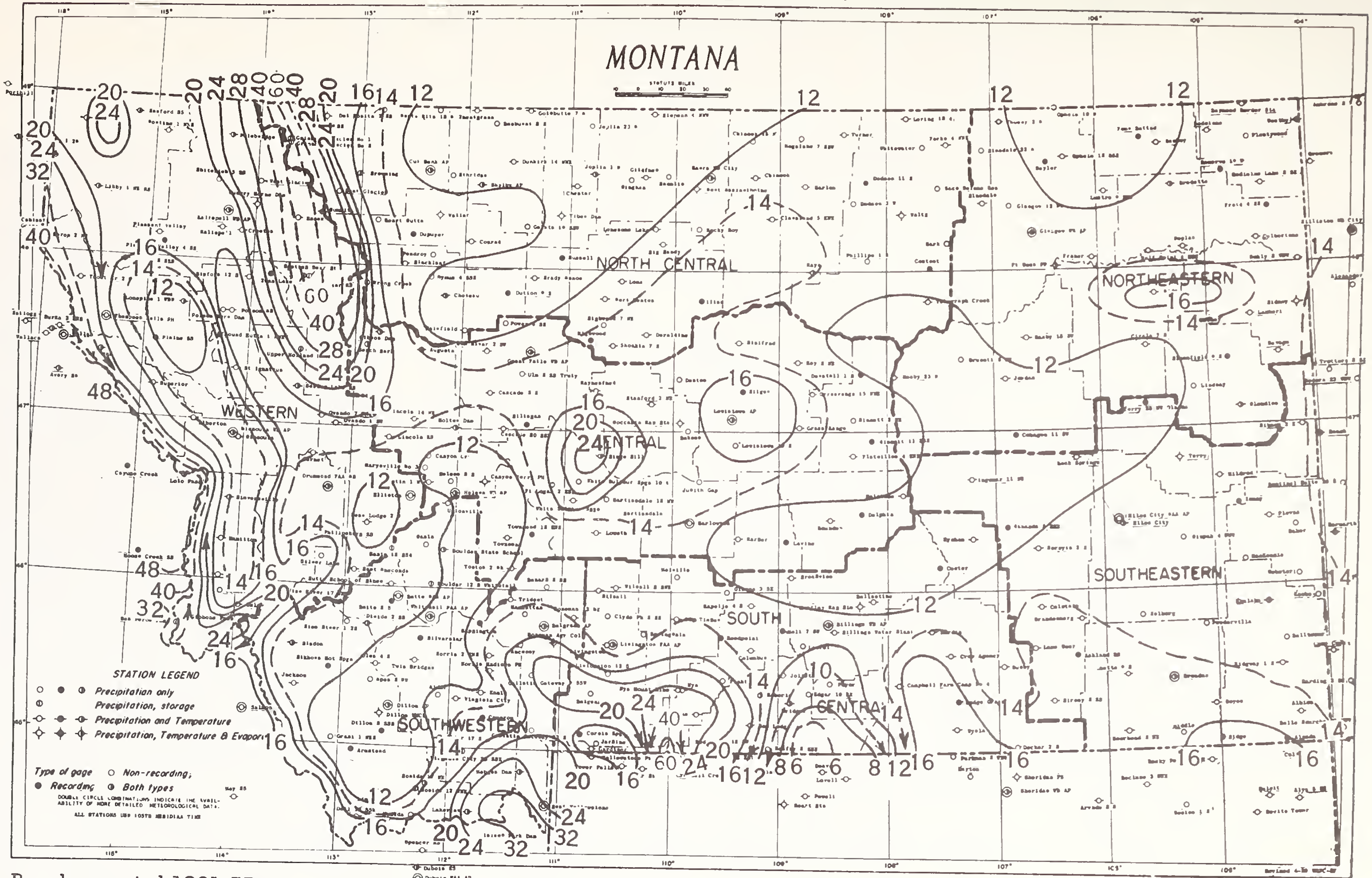
As would be expected in mountain-valley terrain, precipitation patterns show large local variations. Annual precipitation averages vary from around 25 centimeters (cm) (ten inches) in the Deer Lodge valley to as much as 130 cm (50 inches) along the crest of the Bitterroot range. Most valley locations in western Montana receive about 40 cm (15 inches) of precipitation annually. Figure 6 shows mean annual precipitation isopleths for the entire state. In valley locations, as much as a third of the annual total falls during May and June, with a secondary maximum occuring during the winter in the more northern areas. A winter precipitation maximum occurs in some of the higher mountain regions. Snowfall varies greatly with exposure and elevation; annual totals range from as little as 75 cm (30 inches) in some valley locations to as much as 750 cm (300 inches) in some of the higher elevations of the

Table 3.--Average Growing Seasons in Montana

Location	Average Growing Season in Days	Location	Average Growing Season in Days
Augusta	104	Havre	138
Big Sandy	116	Helena	134
Big Timber	123	Jordan	108
Billings	132	Lewistown	107
Boulder	88	Livingston	116
Bozeman	107	Malta	131
Butte	81	Miles City	150
Circle	99	Missoula	128
Deer Lodge	95	Opheim	99
East Anaconda	116	Ovando	39
Flatwillow	122	Poplar	119
Ft. Benton	127	Roundup	129
Glasgow	124	Scobey	116
Glendive	139	Superior	85
Great Falls	135	Thompson Falls	115
Harlowton	96	White Sulphur Springs	97

Source: U.S. Department of Commerce, NOAA, 1971.

Mean Annual Precipitation, Inches



Based on period 1931-55

Isolines are drawn through points of approximately equal value. Caution should be used in interpolating on these maps, particularly in mountainous areas.

Figure 6.--Mean Annual Precipitation, Inches
Source: U.S. Department of Commerce, 1971.

Bitterroots. Thunderstorms occur frequently during the summer months but seldom reach the severe levels experienced further east, and rarely are accompanied by hail. These storms occur on an average of 25 days per year in Missoula and 41 days per year in Butte. The maximum 24-hour rainfall, as reported by National Weather Service (NWS) stations, was 5.89 cm (2.32 inches) at Missoula.

Relative humidity in western Montana averages 60 percent to 70 percent, roughly 10 percent higher than in eastern Montana. Evaporation rates average about 90 cm (35 inches) per year, and there is much cloudiness due to the maritime influence of Pacific air masses. The percentage of possible sunshine is approximately 50 percent on an annual basis, ranging from 30 percent to 40 percent in the winter to near 70 percent in summer.

c. Wind Patterns

In western Montana, surface winds tend to be dominated by local terrain effects. At well-exposed locations, the prevailing flow is from the southwest quadrant. In other locations, however, there is much local variation.

Figures 7 and 8 show wind roses for the Butte airport and the U.S. Department of Energy's MHD-CDIF site, located about two miles southwest of the airport. These data are for the period of December 1976 to February 1977; in each figure, the radial scale represents the percentage of the time that the wind was blowing from a given direction. In spite of the small distance between stations, there is a considerable difference in the prevailing winds at these sites. Both sites show a bimodal distribution. At the MHD-CDIF site, the northwesterly mode is greatly overshadowed by the southwesterly one, while at the airport the northwesterly and southeasterly

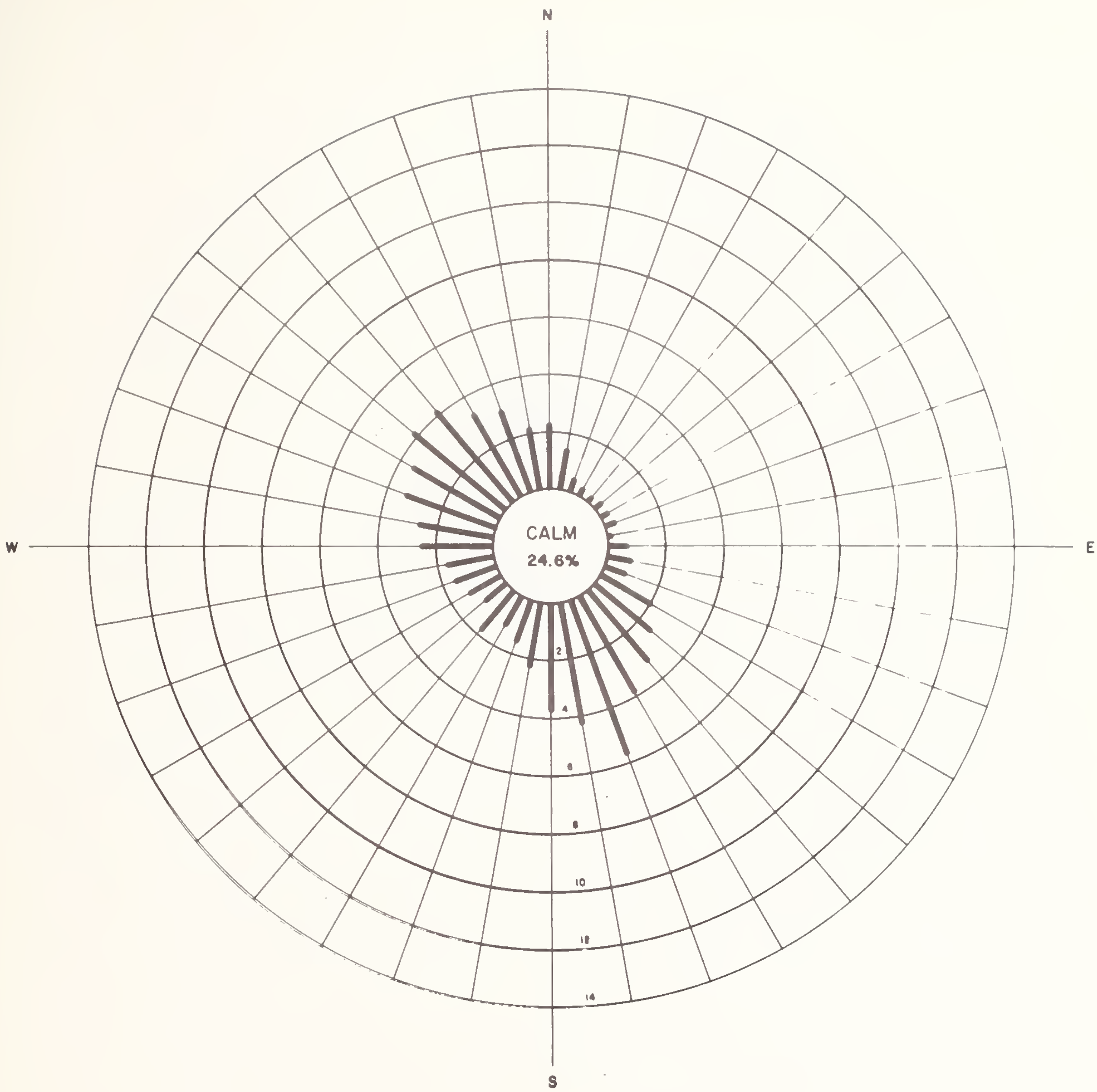


Figure 7.--Wind Rose for Butte Airport, December 1976 through February 1977
Source: Victor F. Garrett, 1977.

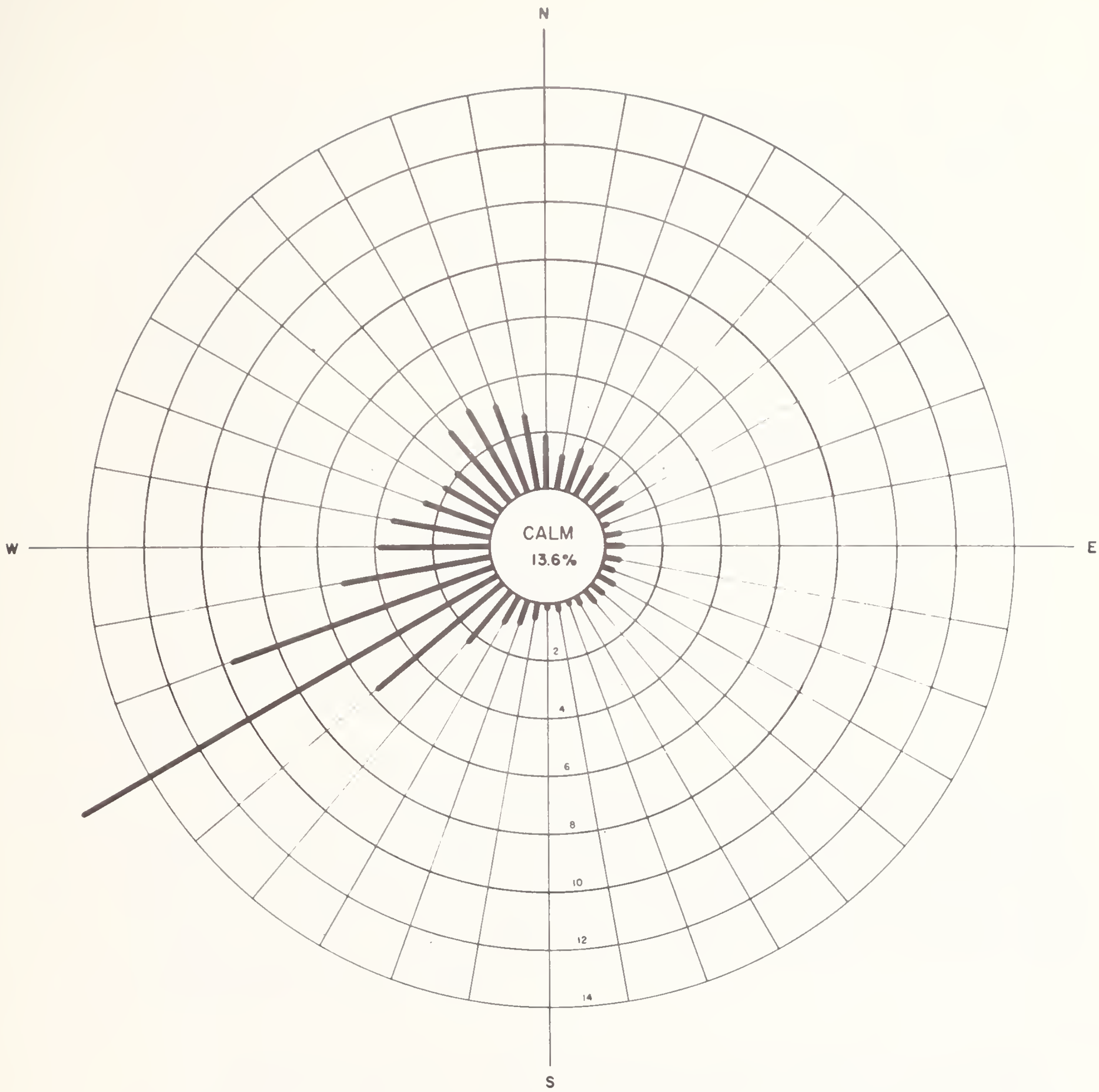


Figure 8.--Wind Rose for Department of Energy MHD CDIF Site, December 1976 through February 1977
Source: Victor F. Garrett, 1977.

directions occur with nearly equal frequencies. The difference between the MHD-CDIF and Butte airport wind roses apparently is caused by topographical variations within the Butte area, which cause differences in airflow patterns at the two sites. This exemplifies the large local airflow variations that can be expected in mountainous regions such as western Montana.

Figure 9 shows a wind rose for Missoula. Northwesterly winds predominate; a secondary maximum is observed for easterly and southeasterly winds. Southwesterly and northeasterly winds are rare. The average wind speed at Missoula is only 2.9 meters per second (ms^{-1}) (6.4 mph) and 50 percent of the observed winds have speeds of 1.4 ms^{-1} (3 mph) or less.

Figure 10 shows a wind rose for Helena. Westerly winds predominate and are the strongest. Winds from the northeast, east, and southeast are almost non-existent and are light when they do occur. Wind speeds of 1.4 ms^{-1} (3 mph) or less occur 34 percent of the time.

These wind roses show that wind directions in western Montana are dominated by terrain influences, and large local variations are present. Wind speeds generally are low; further data on wind speeds are presented in Table 4.

d. Dispersion Potential

Western Montana is characterized by complex terrain features. These often contribute to low wind speeds and high inversion frequencies causing restricted pollution dispersion.

Table 4 shows average wind speeds for 13 locations in Montana; the lowest average speeds occur in the western part of the state, ranging from 3.0 ms^{-1} (6.5 mph) at Missoula to

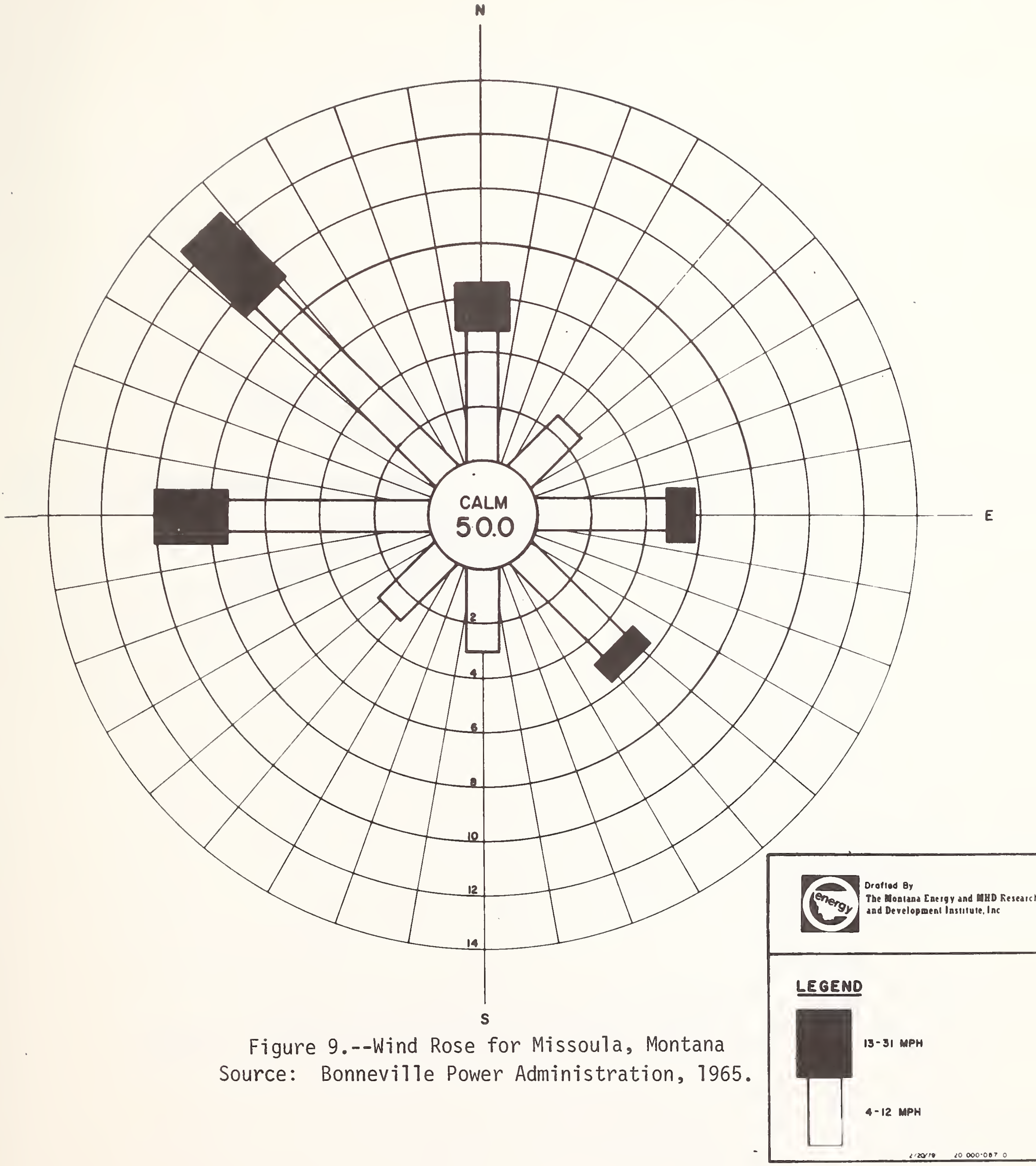


Figure 9.--Wind Rose for Missoula, Montana
Source: Bonneville Power Administration, 1965.

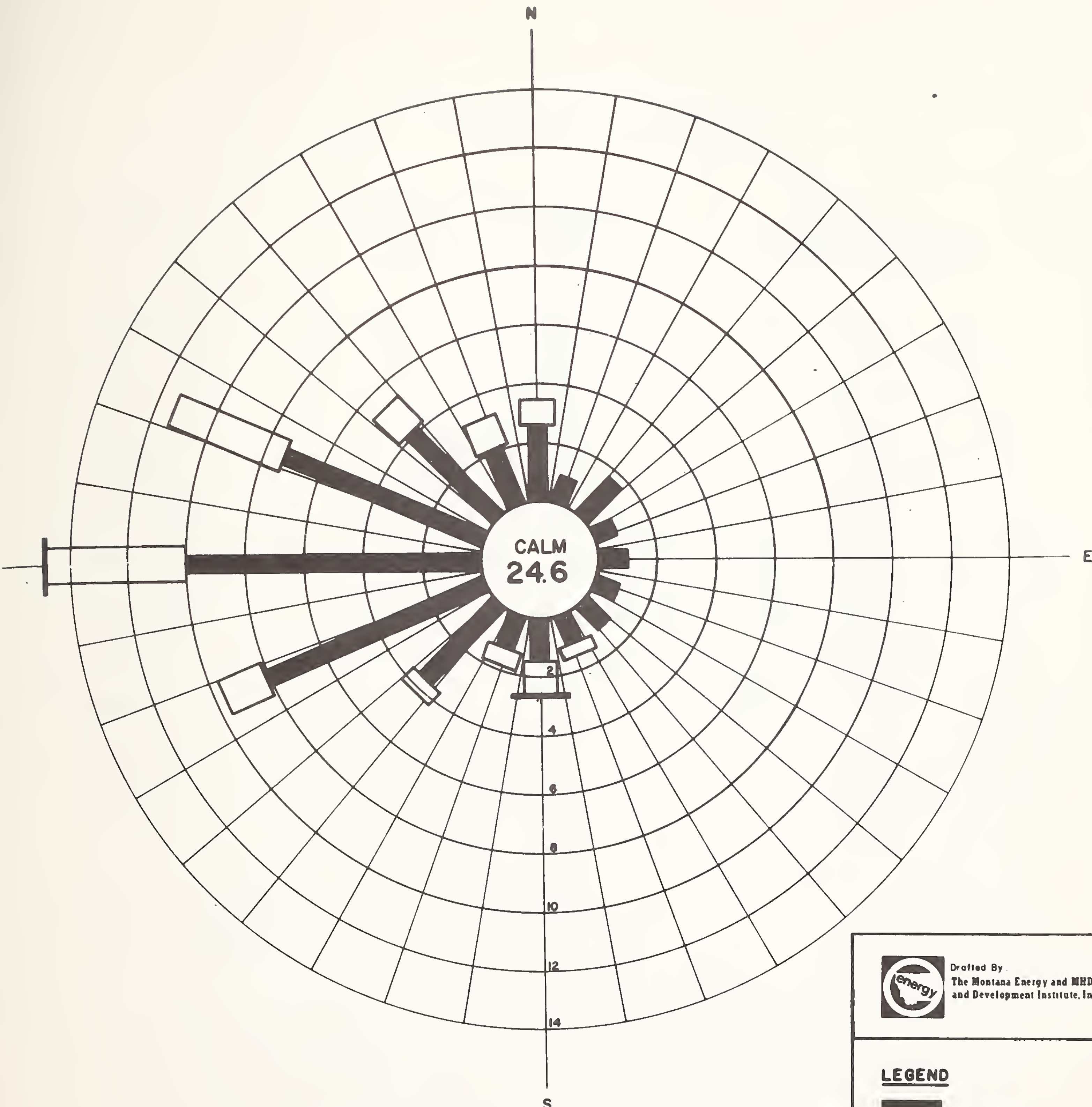


Figure 10.--Wind Rose for Helena, Montana
Source: U.S. Department of Commerce, Data 1949 - 1954.

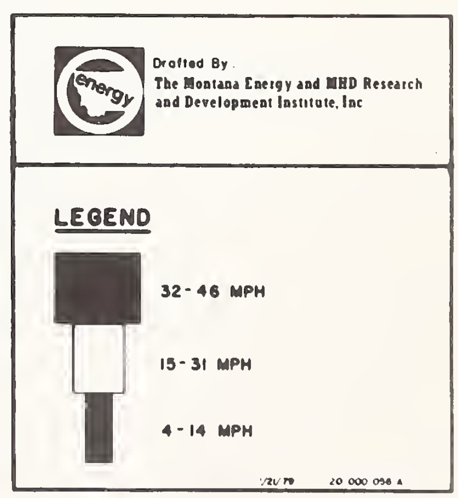


Table 4.--Wind Speed Data for Montana

Location	Mean Annual Wind Speed		Percent of Winds Below 7mph
	mph	m/s	
Livingston	14.1	6.3	23.4
Great Falls	12.4	5.5	25.6
Billings	11.5	5.2	22.7
Glasgow	11.0	4.9	30.5
Miles City	10.8	4.8	26.8
Havre	10.4	4.7	36.9
Lewistown	10.1	4.4	--
Helena	7.9	3.5	56.7
Butte	7.9	3.5	--
Missoula	6.5	2.9	69.5
Bozeman	6.4	2.9	64.6

Source: Obermeir, 1976.

3.6 ms^{-1} (7.9 mph) at Butte. These low wind speeds, together with complex terrain features, indicate that pollutants will disperse slowly in western Montana.

Doty[1] has summarized the percent frequencies of stable, neutral, and unstable atmospheric conditions. This information is presented in Figures 11 through 13 (a key is given in Table 5), and shows that stable conditions occur in western Montana 30 percent to 40 percent of the time. Figures 14 and 15 indicate that inversions occur over western Montana between 37 percent and 40 percent of all hours, and that at least one hour of inversion conditions occurs on about 80 percent of all days.[2] Although these data may be reasonably accurate for many of the broader valleys, acoustic radar data collected by MERDI indicate that inversion conditions are present in Butte at least 50 percent of the time. This discrepancy suggests that in narrow valleys surrounded by high terrain, inversions are more common than indicated by Hosler.[2] Holzworth has summarized average morning and afternoon mixing heights, and these data are presented in Figures 16 and 17; according to Holzworth[3], mixing heights over western Montana average between 400 and 500 m in the morning and near 2000 m in the afternoon, indicating much better ventilation during afternoon hours than in the morning. There is some question about the accuracy of this information, since it was interpolated from a national map and no site specific values were available in western Montana. Because of the very high frequency of nocturnal inversions in western Montana, the mixing height on many mornings is essentially zero; therefore, morning mixing heights given by Holzworth in western Montana may be too high. The afternoon mixing heights probably are more reliable, since afternoon conditions are usually well-mixed. Both morning and afternoon mixing heights in western Montana are lower than in central Montana, but afternoon mixing heights are somewhat higher than in eastern Montana.

Table 5.--Key for Figures 11 through 13

Code Value	Range of Percent Frequency
0	0 - 5
1	6 - 15
2	16 - 25
3	26 - 35
4	36 - 45
5	46 - 55
6	56 - 65
7	66 - 75
8	76 - 85
9	86 - 95
10	96 - 100

Source: Doty, et al., 1976.

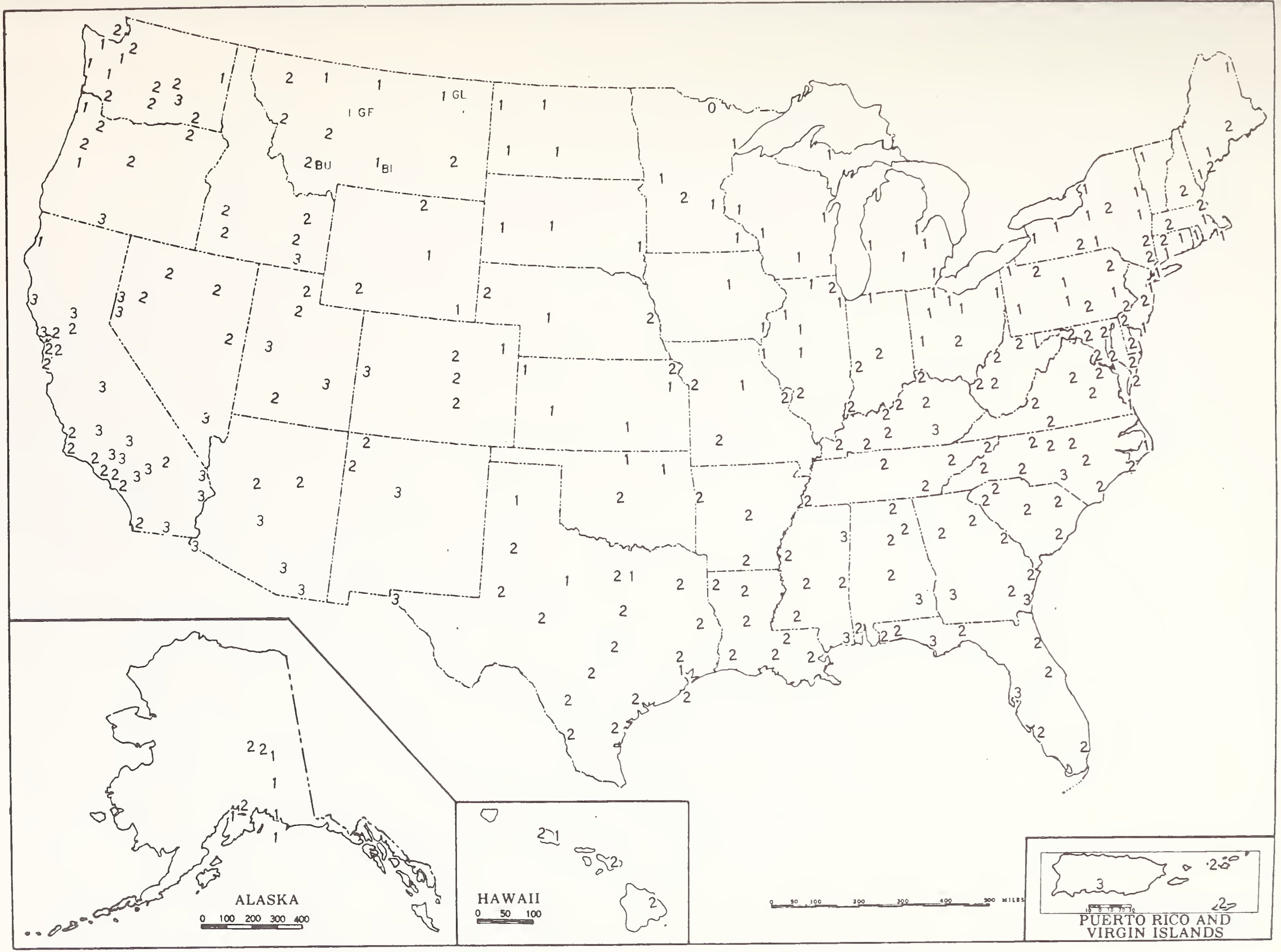


Figure 11.--Percent Frequency - Unstable category - Annual
Source: Doty et.al., 1976.

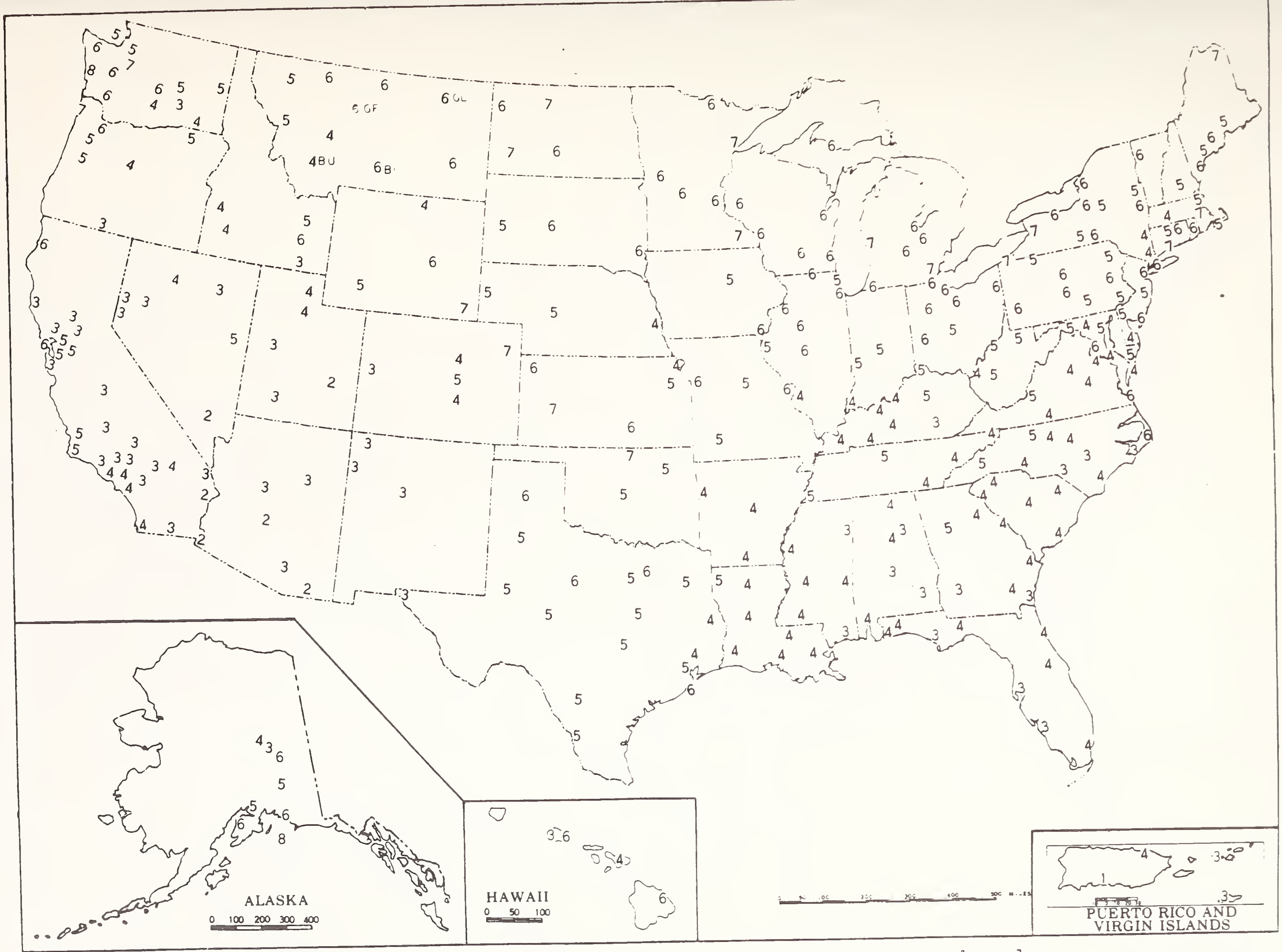


Figure 12.--Percent Frequency - Neutral Category - Annual
Source: Doty et. al., 1976

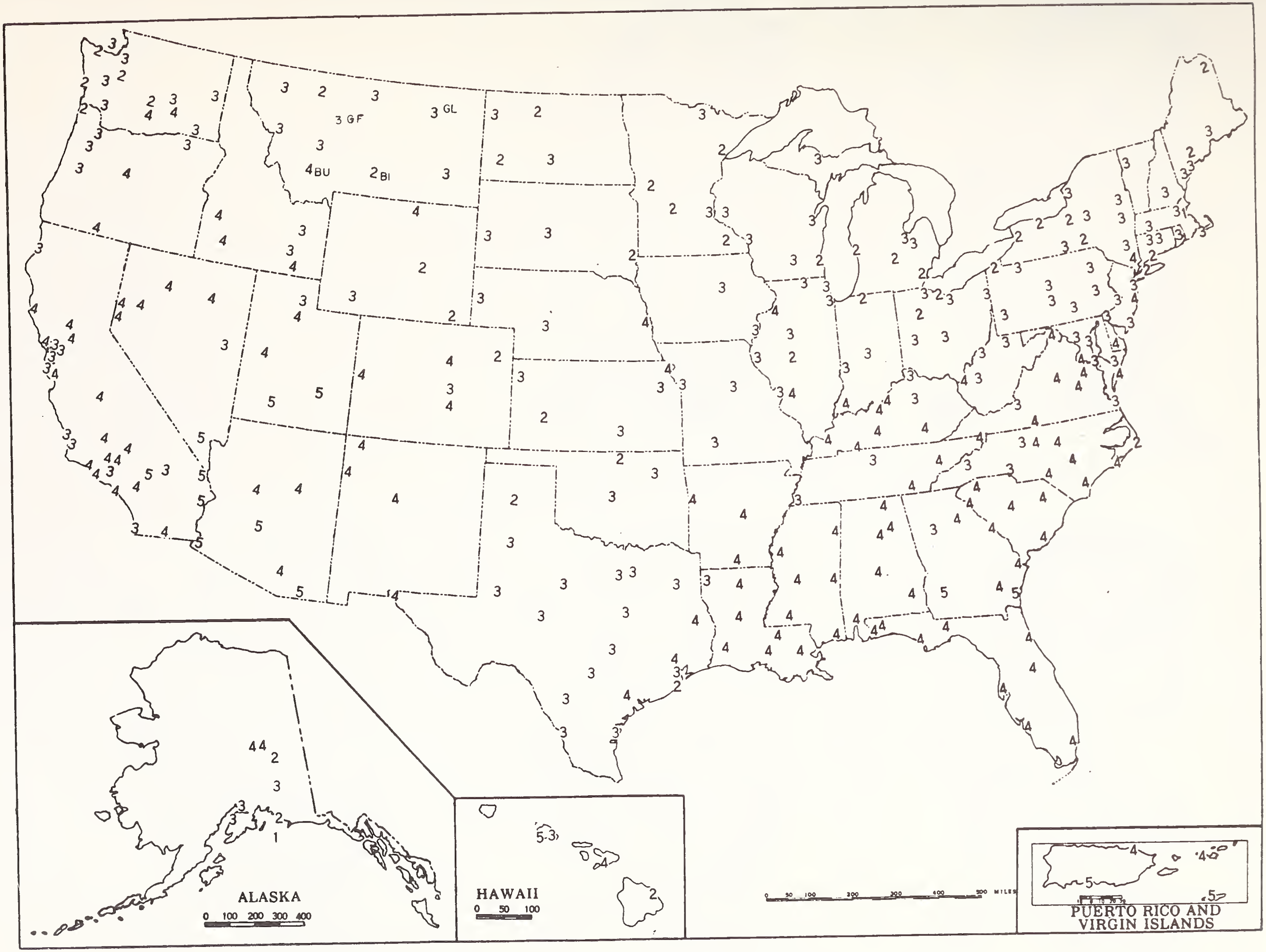
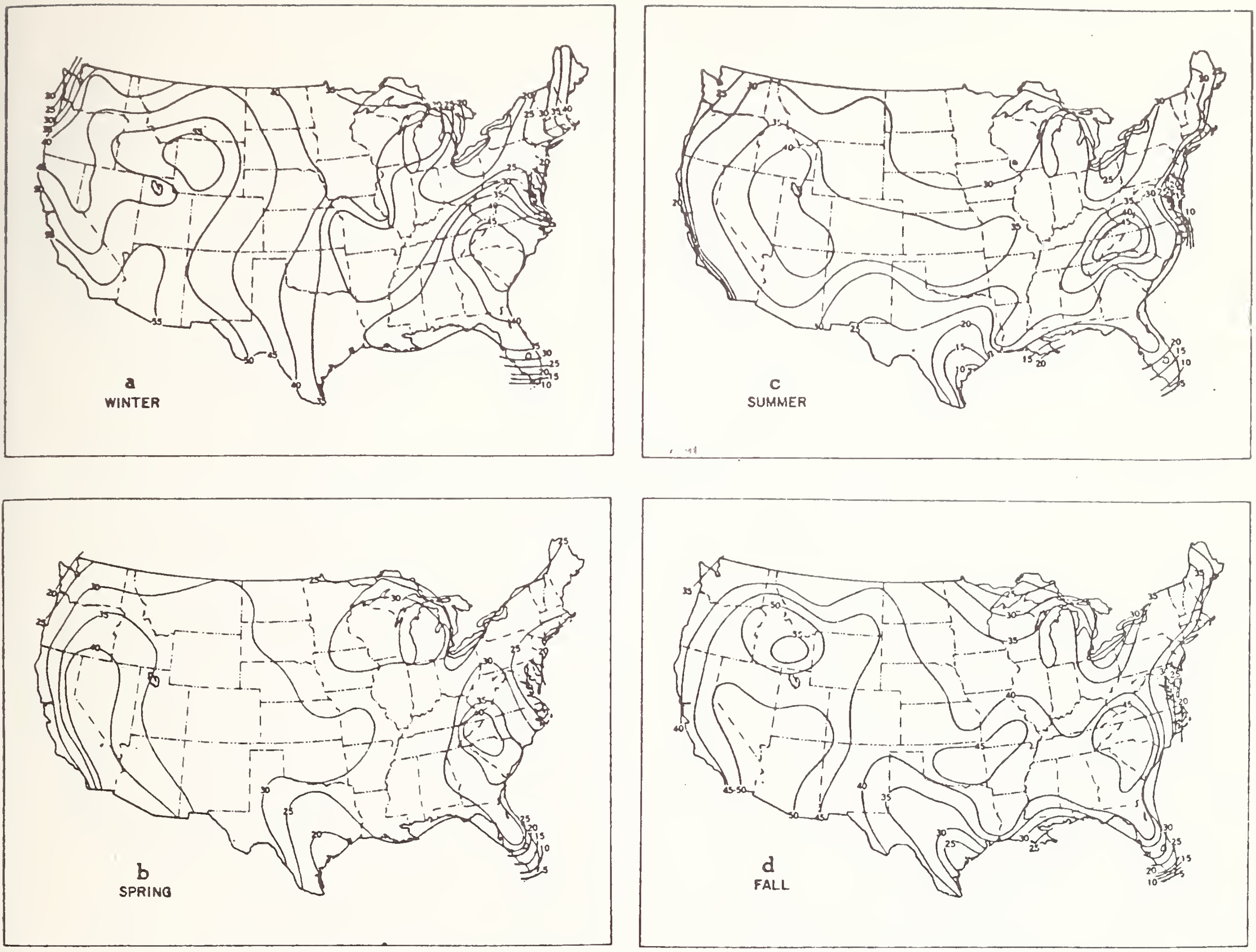


Figure 13--Percent Frequency - Stable Category - Annual

Source: Doty et. al., 1976



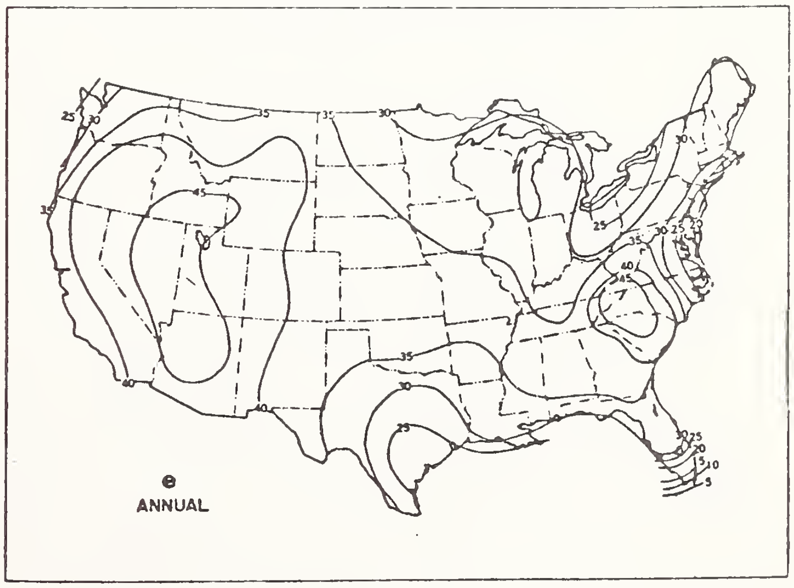
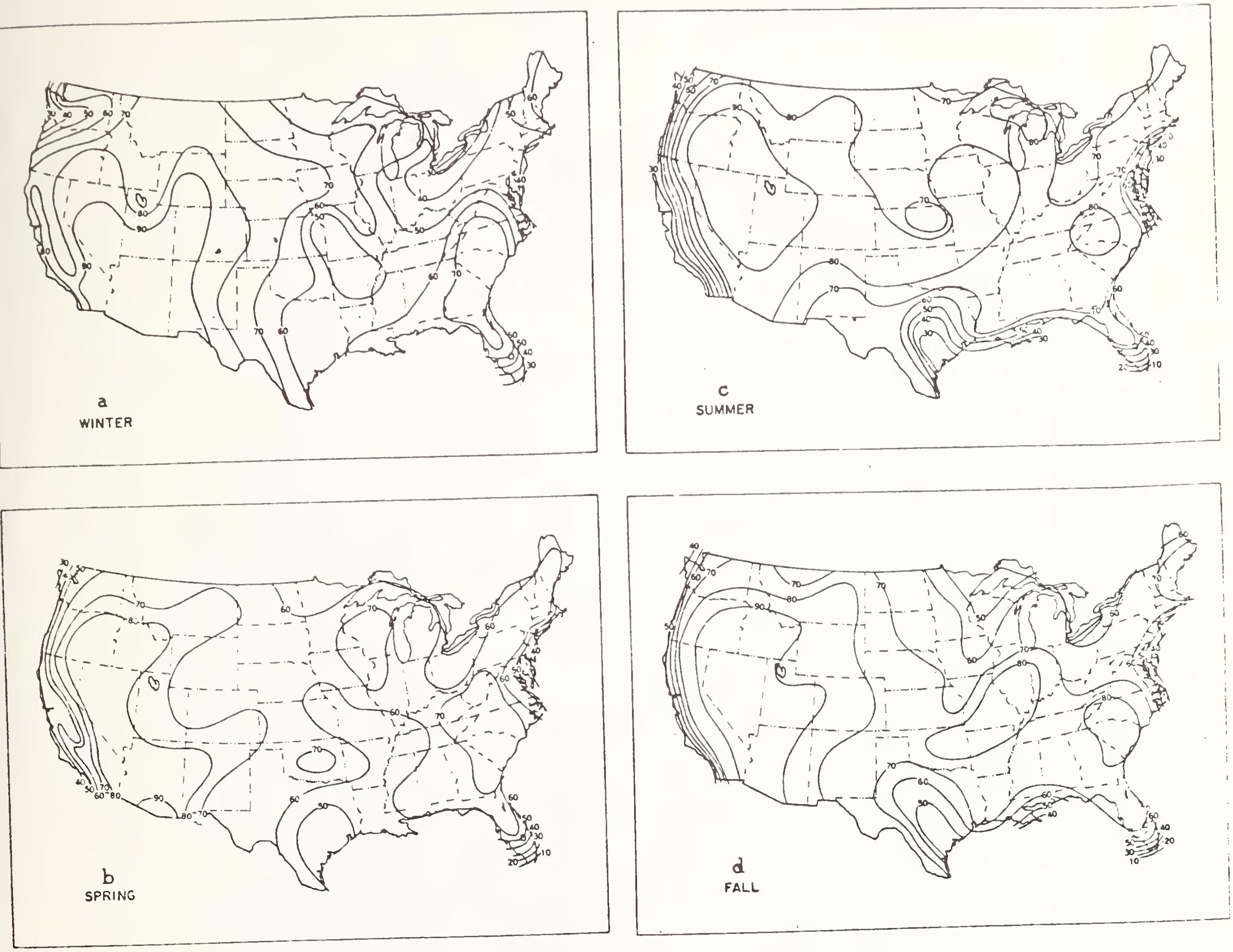


Figure 14.--Inversion frequency (percent of total hours): (A) Winter, (B) Spring, (C) Summer, (D) Fall, (E) Annual.

Source: Hosler, 1961.



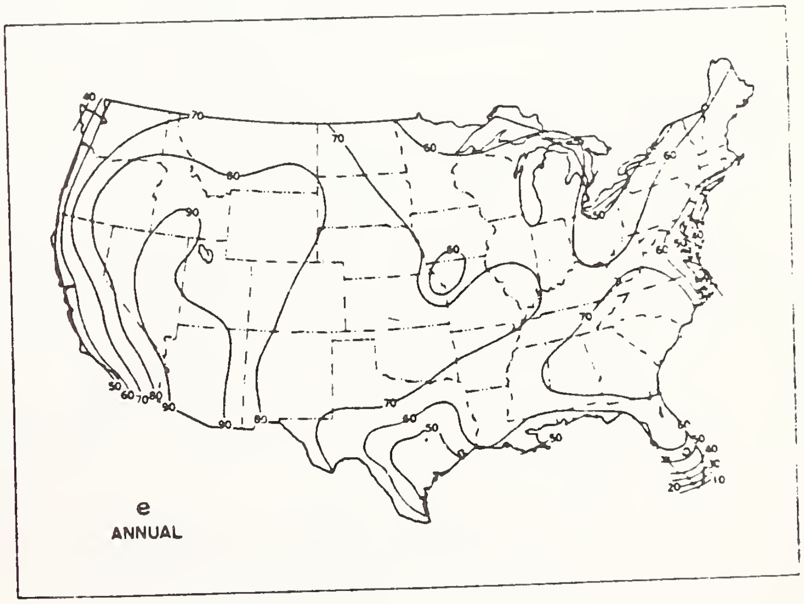


Figure 15.--

—Inversion percent frequency (maximum observed): (A) Winter, (B) Spring, (C) Summer, (D) Fall, (E) Annual.

SOURCE: HOSLER, 1961

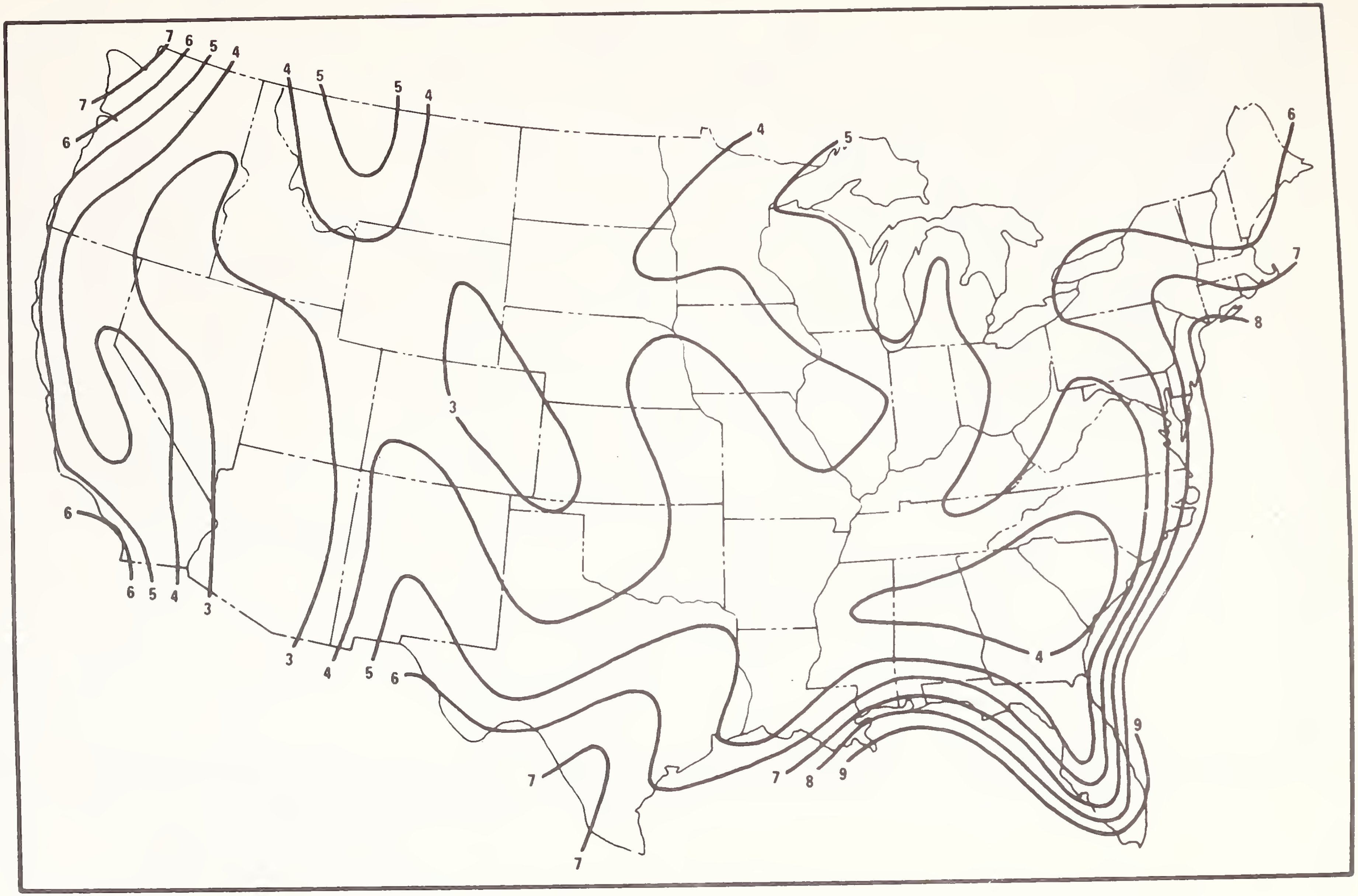


Figure 16.--Isopleths of Mean Annual Morning Mixing Heights (100 m)

SOURCE: HOLZWORTH 1972

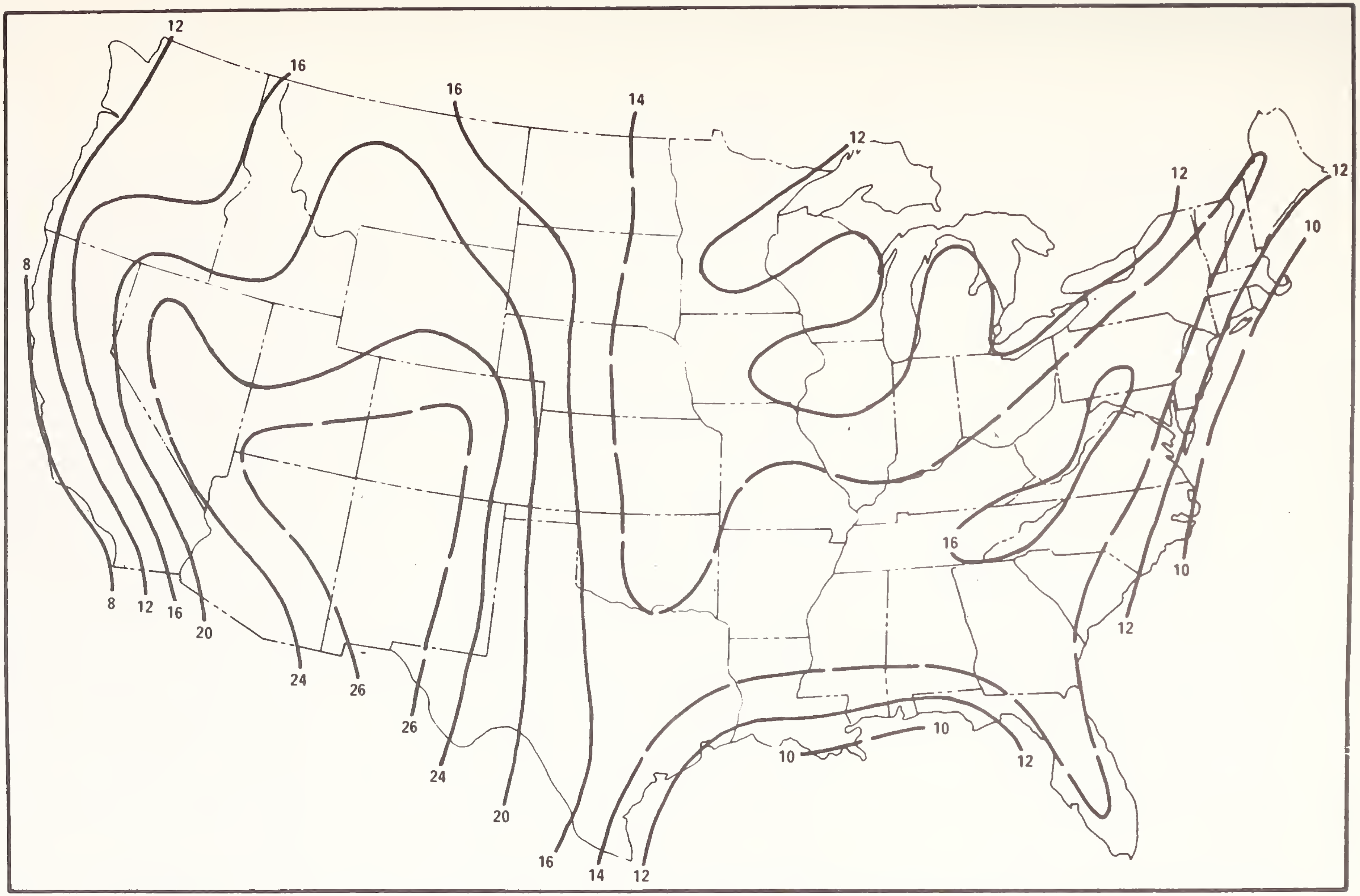


Figure 17.--Isopleths of Mean Annual Afternoon Mixing Heights (100 m)

SOURCE: HOLZWORTH 1972

Rainfall frequency in western Montana is higher than in other parts of the state. In Missoula, precipitation of more than 0.025 cm (0.01 inches) falls on an average of 123 days per year; respective values for Butte and Kalispell are 105 days per year and 132 days per year. This indicates frequent washout of pollutants. However, the complex terrain, low wind speeds, and high inversion frequencies indicate that, relative to other parts of the state, the pollution dispersion potential in western Montana is quite poor.

2. Climate of Central Montana

The proposed pipeline corridor extends eastward through central Montana by way of Harlowton; alternates extend eastward through Great Falls and Bozeman. This area is characterized by a modified continental climate, with more extreme weather than west of the divide. The main moderating influence in this area is the chinook wind, which generally blows from the west and southwest down the east slope of the Rockies and causes temperatures to rise as much as 40^{o}F in a few hours. Because of this feature, most winters are only slightly cooler than in western Montana and are much milder than in eastern Montana.

a. Temperature

The effects of Pacific air masses in central Montana are much weaker than in western Montana because the Continental Divide acts as a barrier, resulting in wider temperature ranges. Figures 2 through 5 show mean maximum and minimum temperatures for January and July for Montana. These maps show more pronounced local temperature variations in this region. Winter temperatures decrease rapidly from southwest to northeast; however, summer temperatures are more uniform. A few polar outbreaks occur each winter, but these tend to be short lived and less severe than further east because of chinook winds which often occur

within a few days. Most winters are slightly cooler than in western Montana, with maximum temperatures averaging between 24^{o} and $36^{o}F$. This area consists both of plains and scattered mountainous regions, so that a large variation of temperature with elevation is observed. Summer maximum temperatures, averaging between 76^{o} and $90^{o}F$, are similar to those in western Montana. Summer minimum temperatures average between 48^{o} and $56^{o}F$, somewhat warmer than in western Montana. The more open topography of this region permits less settling of cold air into valleys than occurs in the more mountainous western region.

The warmer nights during the summer allow a longer growing season in central Montana than in western Montana. The growing season averages between 100 and 140 days in most of this region, but varies greatly with elevation.

b. Precipitation, Evaporation, and Humidity

Precipitation patterns in central Montana differ considerably from those in the west, and show large local variations, caused by the scattered terrain features in this region. Figure 6 shows mean annual precipitation for the state. Annual precipitation ranges from 25 to 40 cm (10 to 15 inches) at the lower elevations to as much as 75 cm (30 inches) in the higher mountains. In valley locations, as much as one half of the annual precipitation falls during May, June, and July, a favorable distribution for farming. Seasonal precipitation variations are more pronounced than in western Montana; a marked precipitation minimum occurs in winter, with the months of October through March receiving as little as a quarter of the annual total. This disparity is less pronounced in the mountains, where heavy winter snows often occur. Annual snowfall ranges from under 75 cm (30 inches) at some lower elevations to over 750 cm (300 inches) in some of the higher mountains.

Severe weather is infrequent near the divide, but becomes more common with eastward progression through the state. Thunderstorms occur frequently during summer months, averaging 30 days per year in Billings and 27 days per year in Great Falls. These sometimes are accompanied by hail, but severe thunderstorms and tornadoes are less frequent here than further east. Frequent strong chinook winds and associated temperature variations can cause damage in this region during winter months.

Relative humidity in central Montana is somewhat lower than in the west, averaging between 55 percent and 65 percent annually. Central Montana receives more sunshine than the west; the percentage of possible sunshine is approximately 60 percent on an annual basis, ranging from 50 percent in winter to 70 percent during the summer.

c. Wind Patterns

Surface winds in central Montana are the strongest in the state. Due to the more open terrain, surface winds are less influenced by topography than in western Montana. In most locations, the prevailing flow is from the southwest.

Figure 18 shows a wind rose for Great Falls. There is a predominance of strong southwesterly winds; southeasterly winds are the least common. Other wind directions are distributed fairly evenly. A minor secondary maximum is observed for northeasterly winds. The high frequency of strong southwesterly winds is a reflection of the downslope winds which often affect this area.

Figure 19 shows a wind rose for Billings, indicating much similarity between winds at Billings and Great Falls. Strong southwesterly winds predominate, again reflecting the many

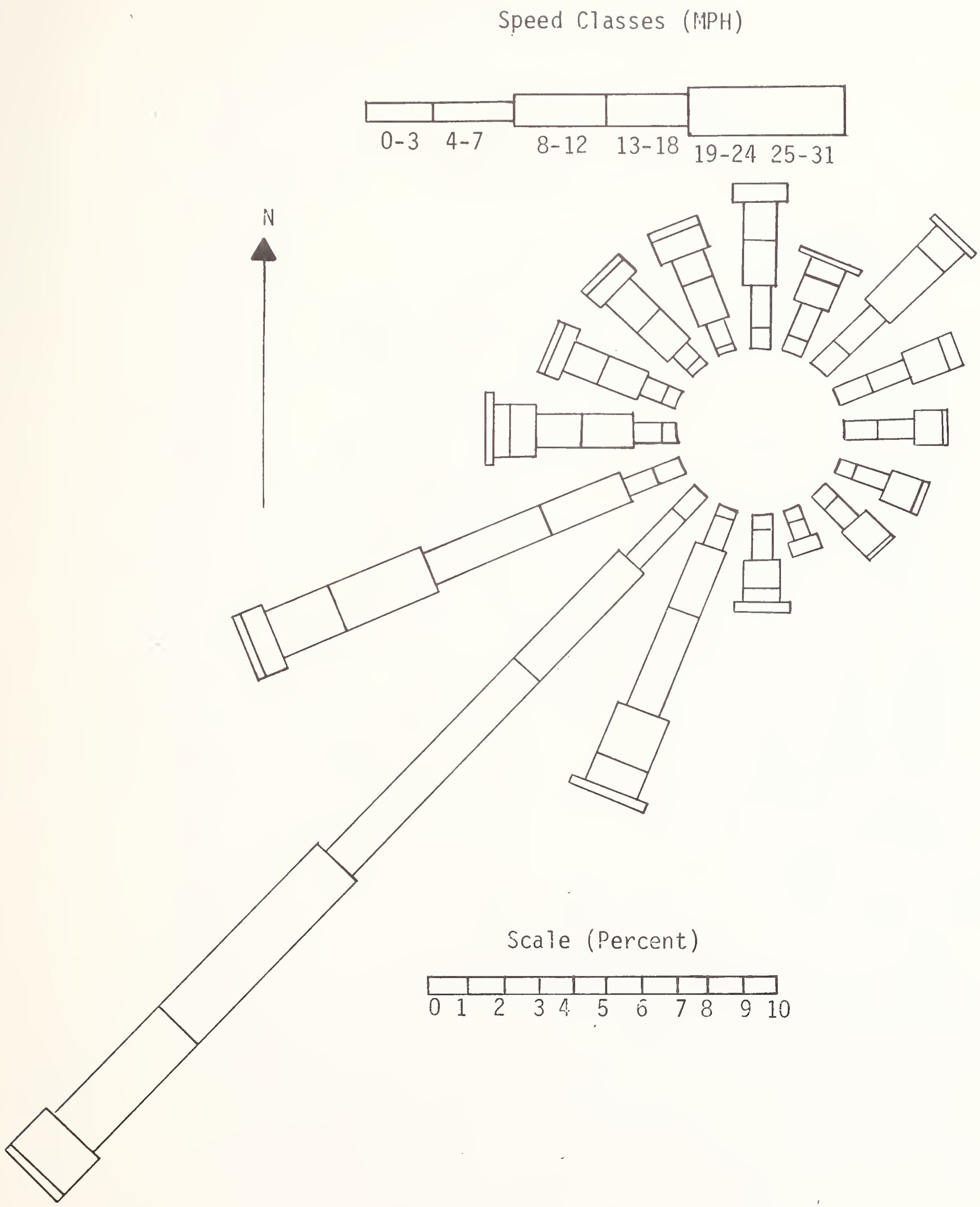


Figure 18.--Wind Rose for Great Falls, Montana
Source: U.S. Department of Commerce, Data 1951 - 1960.

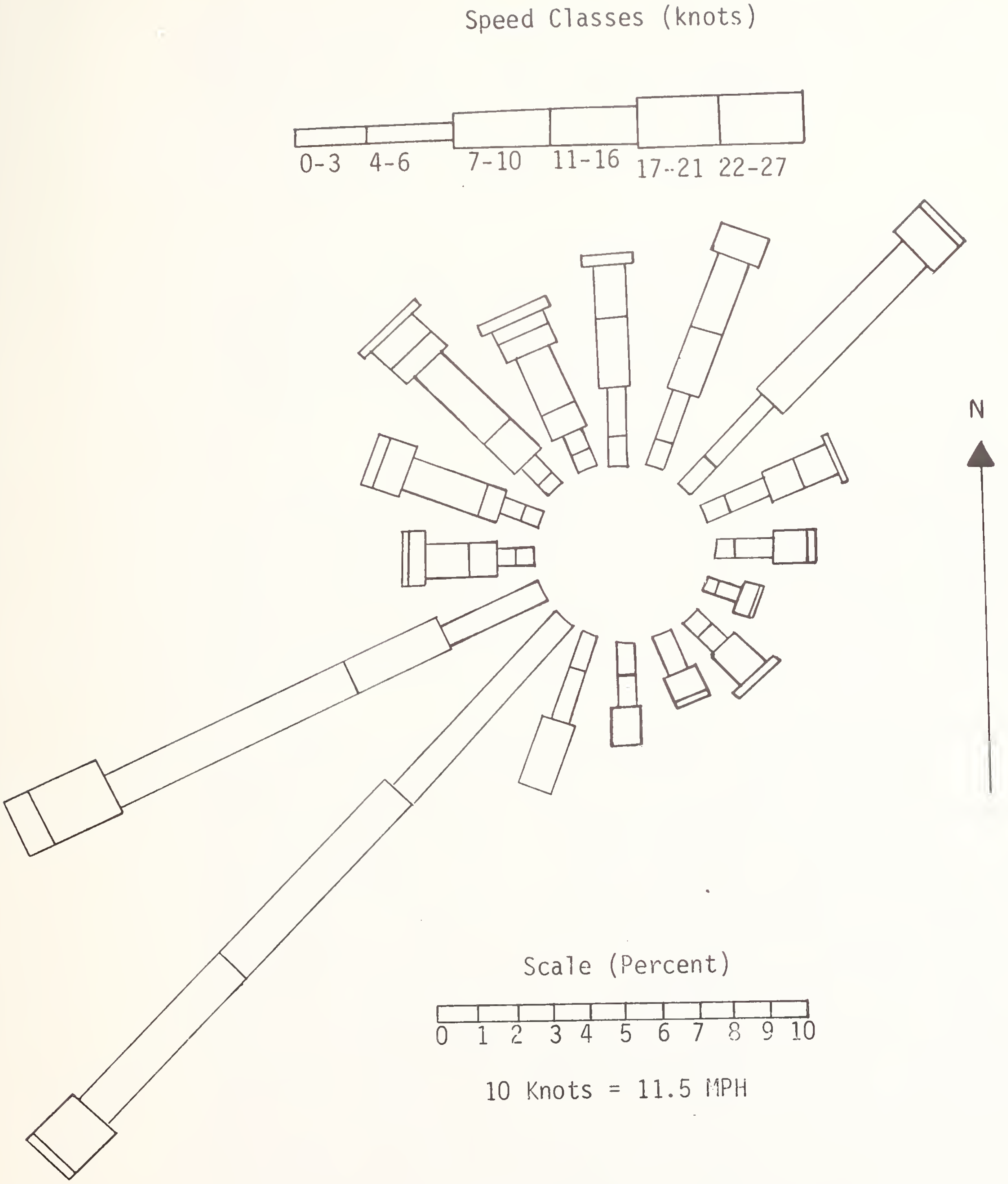


Figure 19.--Wind Rose for Billings, Montana
Source: USAF Air Weather Service, Data 1953 - 1962.

downslope winds in this area. Like Great Falls, a minor secondary maximum is observed for northeasterly winds, and southeasterly winds are the least common.

d. Dispersion Potential

Central Montana consists of plains, broad valleys, and scattered mountain ranges. The more open terrain contributes to much better pollution dispersion conditions than in the mountainous western region.

Table 4 shows that average wind speeds in central Montana are the highest in the state, ranging from 5.2 ms^{-1} (11.5 mph) at Billings to 6.3 ms^{-1} (14.1 mph) at Livingston. These high speeds reflect frequent chinook winds, facilitating very rapid pollutant dispersion in central Montana.

Figure 11 indicates that stable conditions occur in central Montana only about 20 percent to 30 percent of the time, suggesting more favorable dispersion conditions in central Montana than in western Montana. Furthermore, Figure 14 shows that inversion conditions exist between 35 percent and 40 percent of the time, about the same as indicated for western Montana. However, there is reason to believe that values shown in central Montana are more representative of the area, since the terrain is fairly open and site-specific data from Great Falls were used in calculating the inversion frequency isopleths. Evidence presented in Section III.A.1 show that inversion frequency estimates for western Montana are low; thus, there is reason to believe that inversions are less common in central Montana than in western Montana.

Figures 16 and 17 indicate that central Montana has the greatest mixing heights in the state, ranging from about 500 m

in the morning to over 2000 m in the afternoon. These data are probably more reliable than data presented for western Montana, since site-specific data from Great Falls were used for drawing these isopleths.

Rainfall frequency in central Montana is lower than in western Montana, averaging 93 days per year in Billings and 99 days per year in Great Falls. This indicates less frequent washout of pollutants. However, the high wind speeds and mixing heights, together with the low inversion frequencies and fairly open terrain, suggest that central Montana has some of the best pollution dispersion conditions in the state.

3. Climate of Eastern Montana

The proposed and alternate pipeline routes extend through eastern Montana into North Dakota. This area has a well-defined continental climate, with greater temperature and precipitation extremes than in other parts of the state. Significant terrain features are absent; this region is subject to weather influences from all directions.

a. Temperature

Eastern Montana is characterized by very large seasonal temperature variations; both the warmest summers and coldest winters occur in this part of the state. Figures 2 through 5 show mean maximum and minimum temperatures for January and July for Montana. The January maps reflect quite well the influence of arctic air masses in this area; temperatures decrease rapidly from southwest to northeast. Maximum January temperatures range from 28^{o}F in the far southwest to 18^{o}F in the northeast. Average January minimum temperatures range from 10^{o}F in the southwest down to -6^{o}F in the northeast. Combinations of these low temperatures with high wind speeds can result in

very low wind chill factors during winter months. Summer temperatures are the warmest in the state; average maximum temperatures range from 84°F to 90°F, and minimum temperatures range from 52°F to 60°F. The warm summer temperatures are a reflection of the low elevation of this area--generally between 600 and 900 meters (2000 and 3000 feet) (above sea level).

Because of the warmer nights during the summer, growing seasons in eastern Montana are the longest in the state, reaching a maximum of 150 days at Miles City. Growing seasons generally range from 120 days in the far north to over 140 days in much of the south. Local variations in temperature and growing season are less common than further west because of the relatively uniform terrain.

b. Precipitation, Evaporation, and Humidity

Because of the flat terrain and distance from Pacific moisture sources, precipitation patterns in eastern Montana are much different than in the western and central regions. Figure 6 shows mean annual precipitation for the state. Precipitation totals in eastern Montana range from 30 to 40 cm (12 to 16 inches), and there is much uniformity in the area. Great seasonal precipitation variations occur here; at many eastern Montana locations, half of the annual total falls during May, June, and July. Winters are very dry; during the six-month period of October to March, less than one-third of the annual total falls in southeast Montana, and less than one-fourth of the annual total falls in northeast Montana. Snowfall is correspondingly light, ranging from 75 cm (30 inches) in northeast Montana up to 130 cm (50 inches) in southeast Montana.

Severe storms are more common in eastern Montana than elsewhere; hailstorms annually cause significant property damage, mostly during the summer months. Tornadoes occur occasionally. Between 1955 and 1967, 70 tornadoes were reported; property damage totaled $1.6 million. Thunderstorms occur on an average of 28 days per year in Glasgow and 30 days per year in Miles City. Heavy rains occur more frequently than in other parts of the state because of the intensity of thunderstorm activity. At Miles City, the maximum 1-hour rainfall was 3.20 cm (1.26 inches) and the maximum 24-hour rainfall was 9.50 cm (3.74 inches).

Humidity in eastern Montana generally averages between 50 percent and 60 percent. Evaporation rates increase to the east, exceeding 140 cm (55 inches) annually. Sunshine is abundant, averaging over 60 percent of the possible amount.

c. Wind Patterns

Winds in eastern Montana are fairly uniform because of the relatively flat terrain. Wind speeds are moderately high, but not as high as in central Montana. Wind directions are predominantly westerly and northwesterly; southeasterly winds also are prevalent, but to a lesser degree.

Figure 20 shows a wind rose for Glasgow airport. Strong northwesterly winds predominate; a secondary maximum is observed for southeasterly winds. Northeasterly and southwesterly winds are the least common and are usually light.

Figure 21 represents a wind rose for Glasgow Air Force Base, located about 32 km (20 miles) north of Glasgow, and shows marked similarity to winds at Glasgow. Northwesterly winds predominate and a secondary maximum is observed for

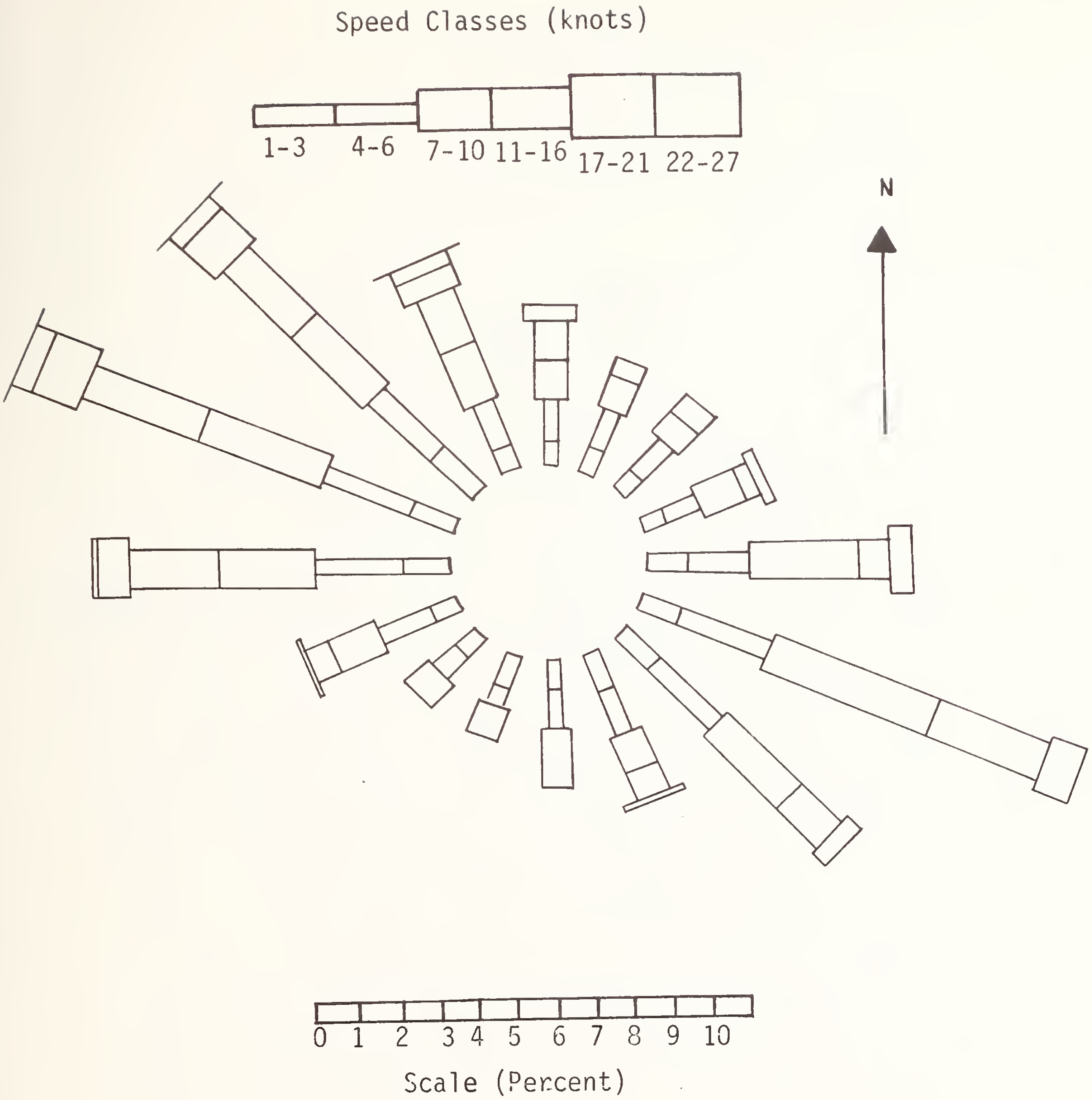


Figure 20.--Wind Rose for Glasgow, Montana
Source: U.S. Department of Commerce.

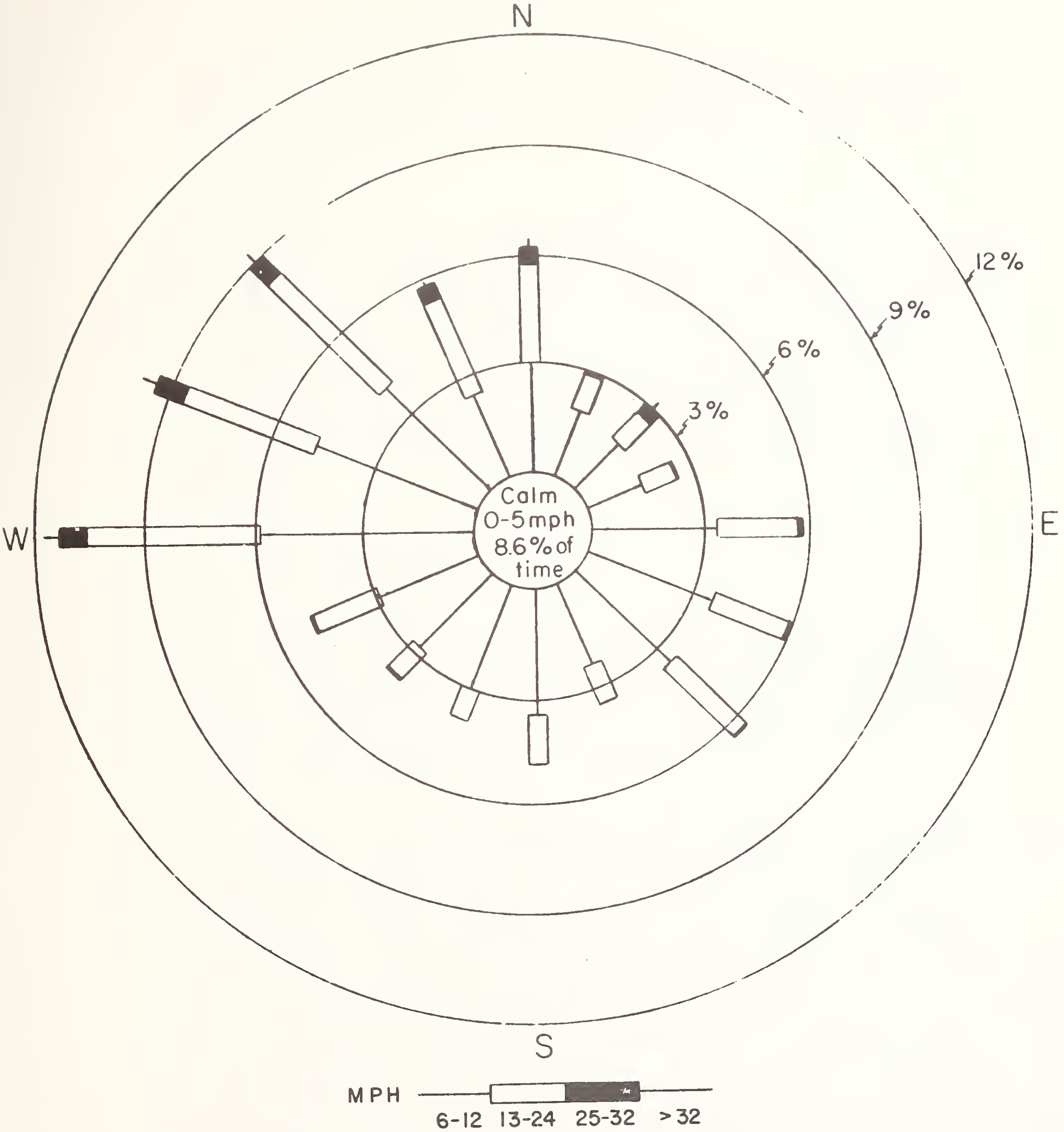


Figure 21.--Wind Speed and Direction for Glasgow, Montana Air Force Base

Source: Strategic Air Command.

southeast winds, although not as pronounced as at Glasgow. Northeasterly and southwesterly winds are infrequent and usually light.

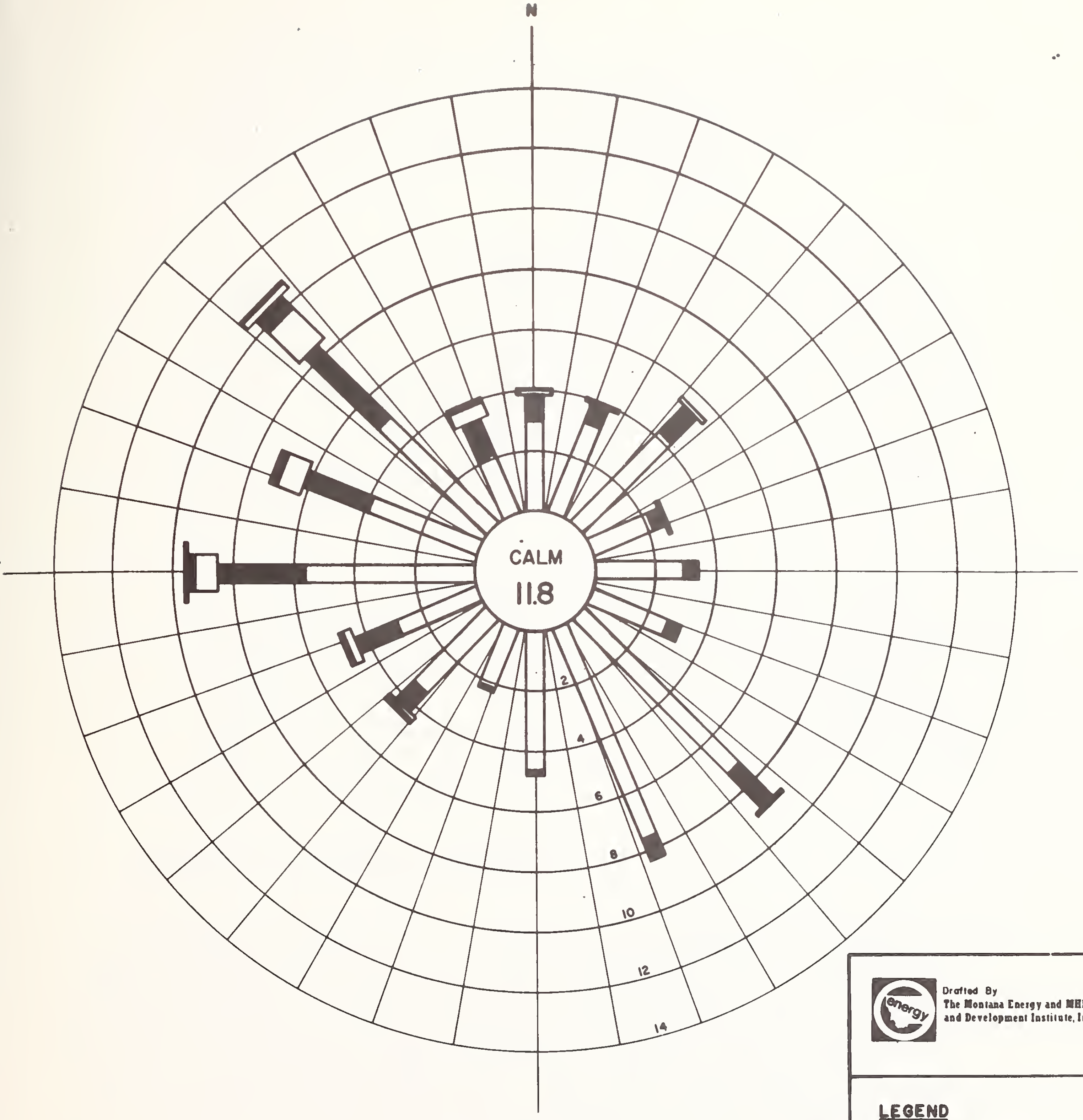
Figure 22 shows a wind rose for Miles City. Like Glasgow, northwesterly and southeasterly winds predominate; southwesterly and northeasterly winds are the least common. The strongest winds are from the northwest. The similarity in wind patterns at Glasgow and Miles City, located 160 km (100 miles) apart, illustrates the uniformity in wind patterns over eastern Montana.

d. Dispersion Potential

Eastern Montana consists of plains and small, rolling hills, suggesting very good pollution dispersion conditions. However, there are other factors to consider, such as wind speed, stability, and mixing height.

Table 4 shows that average wind speeds in eastern Montana are somewhat lower than in central Montana, averaging 4.9 ms^{-1} (10.8 mph) in Miles City and 5.0 ms^{-1} (11.0 mph) in Glasgow, reflecting the absence of chinook winds in the east. This suggests that on some days when strong downslope winds are blowing in central Montana, winds in eastern Montana may be light, contributing to poorer pollution dispersion conditions. These wind speeds imply that eastern Montana has better dispersion than western Montana, but poorer dispersion than central Montana.

Figure 11 illustrates that stable conditions occur about 30 percent of the time in eastern Montana. This indicates more favorable dispersion conditions than in western Montana, but less favorable conditions than in central Montana. As



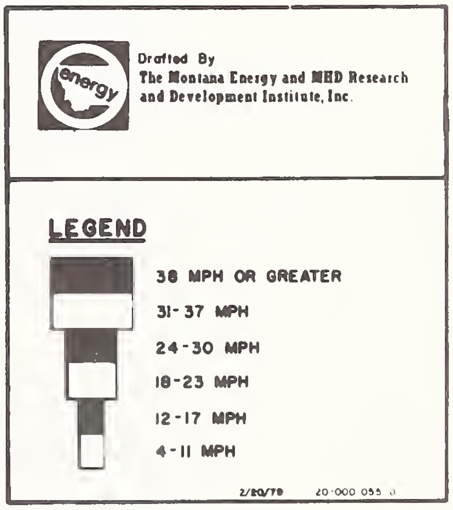


Figure 22.--Wind Rose for Miles City, Montana
Source: U.S. Department of Commerce, Data 1960 - 1964.

shown in Figure 14, inversion conditions occur over much of eastern Montana more than 40 percent of the time, again suggesting better dispersion conditions than in western Montana, but poorer conditions than in central Montana.

Figures 16 and 17 show that mixing heights in eastern Montana are much lower than in central Montana, ranging from under 400 m in the morning to between 1500 m and 2000 m in the afternoon. This indicates potentially restrictive ventilation. Rainfall frequency in eastern Montana is the lowest in the state, averaging 87 days per year in Glasgow and 92 days per year in Miles City, so that less washout of pollutants will occur in this region.

The data presented here, in addition to the terrain characteristics, suggest that the pollution dispersion potential in eastern Montana is significantly better than in western Montana. However, it is not as good as in central Montana, because of lower wind speeds, lower mixing heights, and greater inversion frequencies.

B. Inventory of Existing Air Quality

Throughout Montana, the air quality varies widely from pristine in remote, undeveloped regions, to levels exceeding national ambient air quality standards in several populated and industrial areas. Along the Northern Tier pipeline study corridors in Montana, the air quality is largely unmeasured (see Figure 23). Data gathering efforts are focused on areas with an existing air quality problem or where future degradation is anticipated.

This inventory describes the ambient air environment within the proposed Northern Tier corridor and within alternate corridors outlined by the Montana Department of Natural Resources and Conservation (DNRC). Montana Air Quality Bureau (AQB) data were judged most useful for this report for the following reasons:

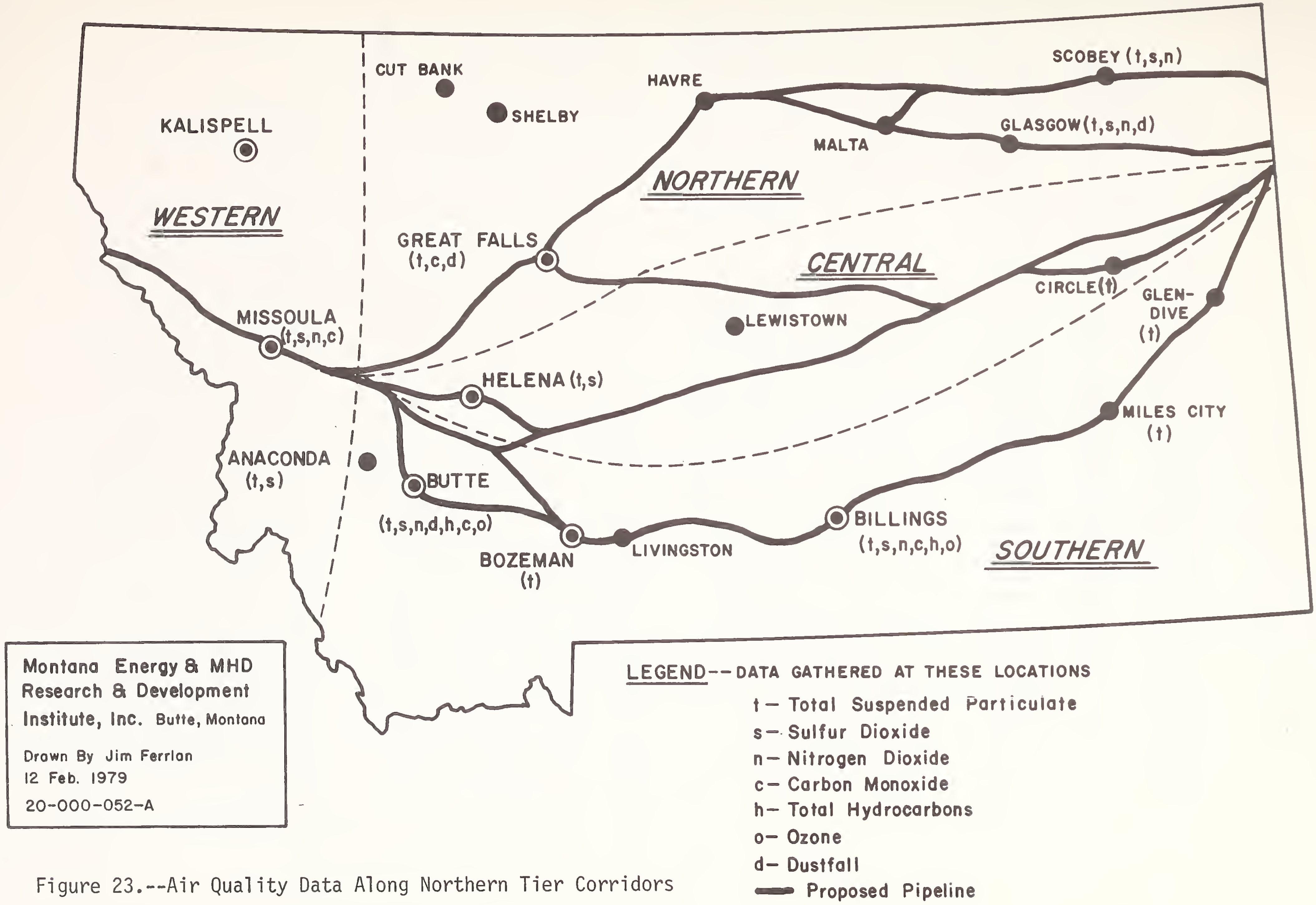


Figure 23.--Air Quality Data Along Northern Tier Corridors

- The AQB has the most comprehensive monitoring network in the state;
- Other data sources (e.g., industry) were not summarized and tend to duplicate state work; and
- Data collected by the AQB is consistent and comparable.

MERDI has collected data in the Butte valley and at Glasgow Air Force Base; this air quality data is used to strengthen state information in these areas.

As shown in Figure 23, this assessment is broken into four sections· western corridors, northern corridors, central corridors, and southern corridors. Division of the corridors in this manner facilitates the description of the existing air quality. Each of the four sections includes an evaluation of nearby Prevention of Significant Deterioration (PSD) Class I areas, existing air quality, non-attainment areas, and emission sources within and near the corridors.

Under the Clean Air Act and subsequent amendments, national ambient air quality standards (NAAQS) (see Table 6) were established by the Environmental Protection Agency (EPA). All states then were required to adopt ambient air standards at least as stringent as the NAAQS (Montana ambient air standards are shown in Table 7). Areas of the country are evaluated to determine if the NAAQS are met. If standards are not met, the area is designated "non-attainment" and a compliance plan is required; if the ambient air is cleaner than NAAQS, it is subject to regulation under the PSD portion of the Clean Air Act Amendments.

Non-attainment areas are subject to an emission-offset policy that requires new source applicants in an area to assure that existing sources reduce emissions by an amount equal to or greater than those expected from the new source. In areas where air quality is better than NAAQS, PSD regulations require class rating designations. The importance of air quality preservation is used to determine the class rating (I, II, or III), which limits the incremental deterioration of existing air

Table 6.--National Ambient Air Quality Standards

	Primary Standard	Secondary Standard
Particulate		
24-hour average	260 ug/m^3	150 ug/m^3
Annual geometric mean	75 ug/m^3	60 ug/m^3
Sulfur dioxide		
3-hour average		0.5 ppm
24-hour average	0.14 ppm	
Annual average	0.03 ppm	
Carbon Monoxide		
1-hour average	35 ppm	35 ppm
8-hour average	9 ppm	9 ppm
Ozone		
1-hour average	0.08 ppm	0.08 ppm
Nitrogen dioxide		
Annual average	0.05 ppm	0.05 ppm
Lead		
Calendar quarter	1.5 ug/m^3	1.5 ug/m^3

Source: 40 Code of Federal Regulations, 50.1, 1978.

Table 7.--Montana Ambient Air Quality Standards

Pollutant	Standard	Averaging Time
Suspended Particulates	75 ug/m^3 200* ug/m^3	Annual 24-Hour
Sulfur Dioxide	0.02 ppm 0.10^+ ppm 0.25^a ppm	Annual 24-Hour 1-Hour
Settled Particulates	15 T/mi^2/month (residential area)	3-Month
	30 T/mi^2/month (industrial area)	3-Month
Suspended Sulfates	4 ug/m^3 12^b ug/m^3	Annual --
Reactive Sulfur	0.25 mg SO_3/ 100 cm^2/day	Annual
	0.50 mg SO_3/ 100 cm^2/day	1-Month
Fluorides, Total in air (as HF)	1 ppb	24-Hour
Fluorides (Gaseous)	0.3 ug/cm^2/28 days	28-Days

[a]Not to be exceeded for more than one hour in any four consecutive days.

[b]Not to be exceeded more than one percent of the time.

*Not to be exceeded more than one percent of the days in a year.

+Not to be exceeded more than one percent of the days in a 3-month period.

Source: Montana Air Quality Bureau, 1979.

quality. Class increments (shown in Table 7), specify the amount of particulates and sulfur dioxide that can be added to the existing baseline levels. Regulations for other criteria pollutant increments are pending. Class I increments limit industrial development within and in close proximity (i.e., within 100 km) to designated PSD Class I areas. In Montana, numerous wilderness areas and wildlife refuges and one Indian reservation have been designated PSD Class I by the EPA. Because these areas could affect pipeline routing, they will be discussed in the report.

Overlay maps and rating tables were produced by MERDI for DNRC as part of this assessment. Figure 24 is an index map which illustrates the coverage of the 22 overlay rating maps. Comprehensive information on the climate and air quality along the proposed route can be obtained from these maps.

1. Western Corridors

The western corridor includes those segments of the alternate and proposed pipeline corridors from the entrance to Montana near Thompson Falls to Ovando, Avon, and Garrison. Figure 23 graphically delineates the routes described above.

a. PSD Class I Areas

A number of designated PSD Class I areas may be close enough to the proposed and alternate corridors to be influenced by emissions from pipeline construction and operations. As shown in Figure 25 the Mission Mountains Wilderness, Selway-Bitteroot Wilderness, and Bob Marshall/Scapegoat Wilderness are within 48 km (30 miles) of the corridors. Furthermore, the Cabinet Mountains Wilderness is within 96 km (60 miles) of the Thompson Falls area. Future industrial development in this region may be restricted by the presence of these air quality protection areas.

Table 8.--Prevention of Significant Deterioration Allowed Increase Above 1974 Pollution Levels

	Federal Standard	Class I	Class II	Class III
Particulates				
24-hour (ug/m^3)	150	10	37	75
Annual	75	5	19	37
Sulfur Dioxide				
3-hour (ppm)	0.5	0.01	0.20	0.27
24-hour (ppm)	0.14	0.002	0.035	0.07
Annual (ppm)	0.03	0.0008	0.008	0.016

Source: Federal Register, Volume 43, No. 118, June 19, 1978.

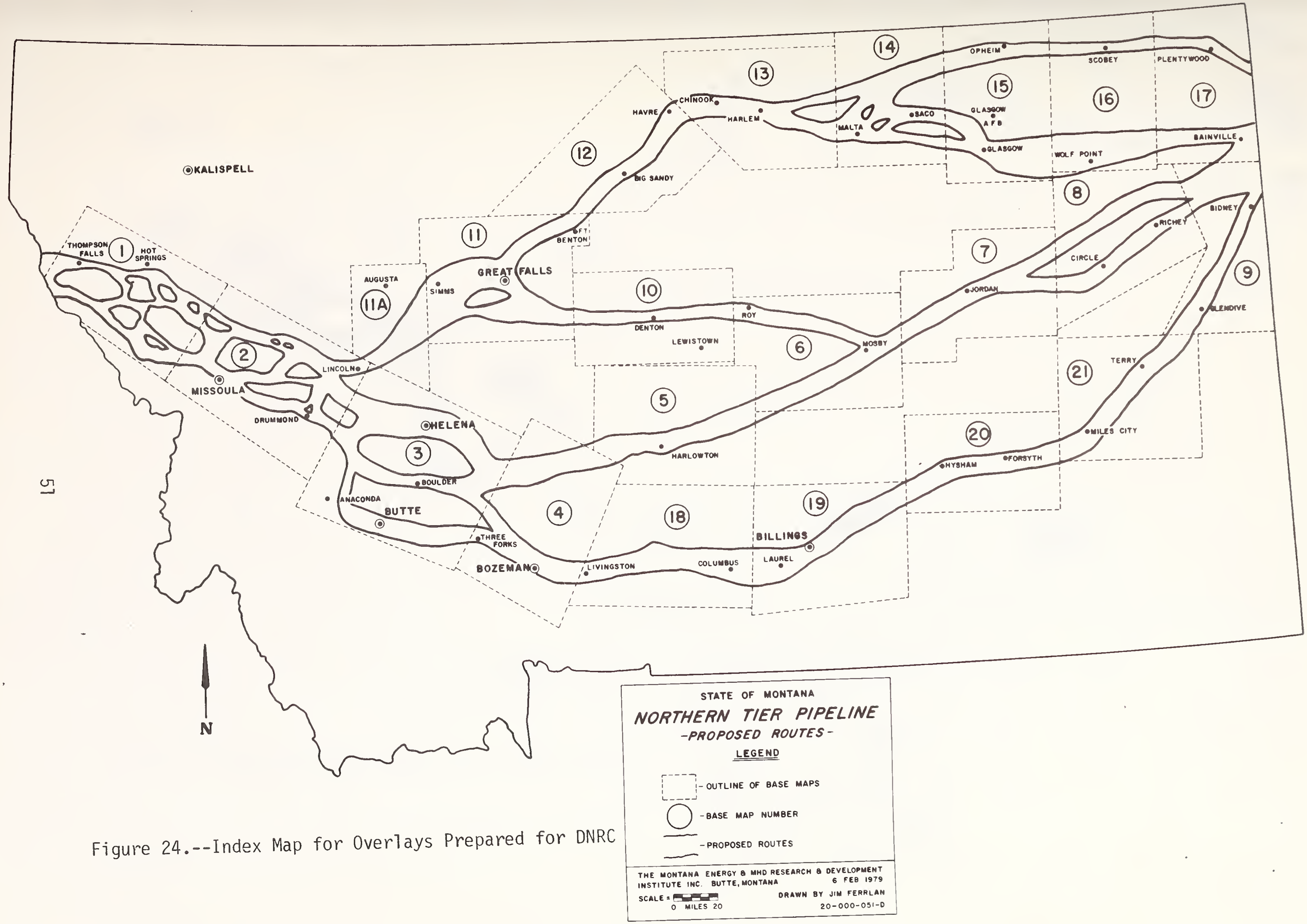


Figure 24.--Index Map for Overlays Prepared for DNRC

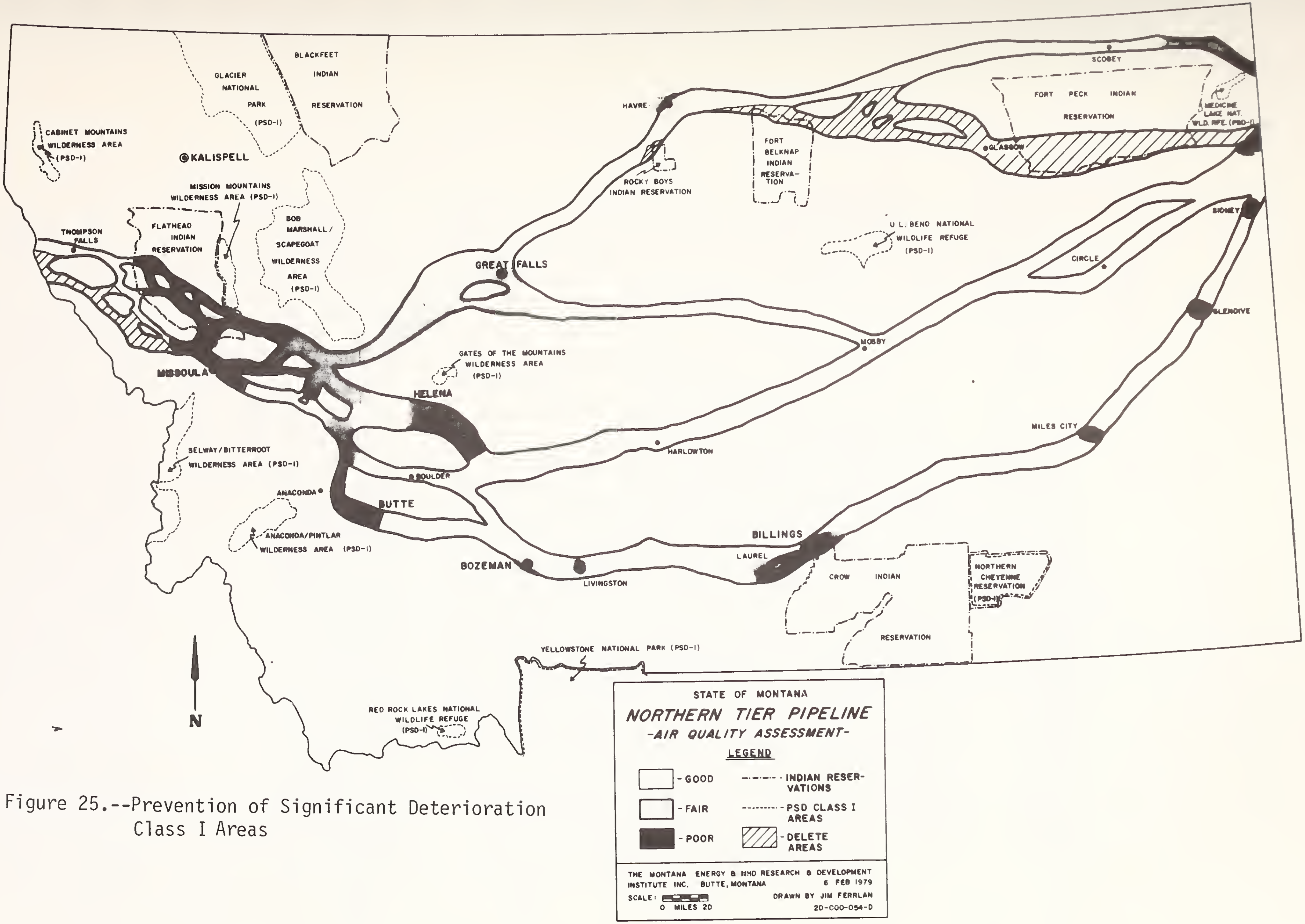


Figure 25.--Prevention of Significant Deterioration Class I Areas

b. Ambient Air Quality

Missoula is the only area that has sufficient air quality data for accurate evaluation. Other parts of the corridors are expected to have good air quality.

The city of Missoula has been designated non-attainment for carbon monoxide (CO) and total suspended particulate (TSP). Data show numerous CO 8-hour averages above 9 parts per million (ppm), with a maximum 8-hour average of 13.87 ppm. The TSP designation was based on an annual mean of 77.4 micrograms per cubic meter ($\mu g/m^3$) and several days above the 24-hour primary standard (260 $\mu g/m^3$). During 1977, particulate levels were in excess of both federal primary and state ambient air quality standards at several locations in the Missoula area. Four sites recorded readings in excess of the federal primary standard, with a maximum 24-hour reading of 335 $\mu g/m^3$ and a maximum annual geometric mean of 82.8 $\mu g/m^3$, according to Gelhaus, *et al.*[4] Table 9 summarizes pollutant concentrations measured in Missoula during 1977 and 1978, indicating that the Missoula valley has an existing air quality problem.

The remainder of the western section was judged to have air quality better than national and state standards. Monitoring recently was initiated in Thompson Falls by the Montana Air Quality Bureau, but sufficient data was not available for inclusion in this report.

c. Emission Sources

Several emission sources contribute air pollution to the Missoula area. A pulp and paper mill, two plywood plants, and a particleboard plant are the major sources; in addition, a number of sawmills also contribute emissions to Missoula's air.[4] Table 10 summarizes emission estimates for the major

Table 9.--Summary of Selected Ambient Air Quality Data (1977)

Pollutant and Averaging Time	Missoula	Anaconda	East Helena	Great Falls	Billings	Colstrip
Sulfur Dioxide						
Max. 1-hr. (ppm)	0.05*	2.00	0.88	---	0.20	0.10
Max. 24-hr. (ppm)	0.02*	0.78	0.26	---	0.02	0.05
Annual (ppm)	0.00*	0.038	0.019	---	0.002	0.00
Particulates						
Max. 24-hr (ug/m^3)	676*	161	192	869	165	95
Annual Geo. Mean	82*	44	103	52	58	28
Settled Particulate (gm/m^2)	---	---	---	10.7	---	---
Visibility						
Annual (Miles)	**	---	---	65	60	---
Carbon Monoxide						
Max. 1-hr. (ppm)	31.6	---	---	23.1	19.2	0.0***
Max. 8-hr. (ppm)	25.9	---	---	14.4	13.1	0.0***
Ozone						
Max. 1-hr. (ppm)	0.075*	**	---	---	0.08	0.050***
Nitrogen Dioxide						
Max. 1-hr. (ppm)	0.098*	**	---	---	0.180	0.130
Annual Arith. Mean	**	**	---	---	0.029	0.029
Hydrogen Sulfide						
Max. 30 min. (ppm)	0.0561	---	---	---	---	---
Annual Arith. Mean	0.0006	---	---	---	---	---
Total Hydrocarbons						
Max. 1-hr (ppm)	7.92	---	---	---	26.40	3.50***

* = 1978 Data
** = Insufficient Data
--- = No Data
*** = 1975 to 1976 Data

Source: Gelhaus et al., 1978; Trijonis and Shapland, 1978; Unpublished Air Quality Bureau data, 1978.

Table 10.--Missoula Area Estimated Emissions - 1977

Sources	Estimated Emissions Sulfur Dioxide	(Tons Per Year) Particulates
Point Sources		
Anaconda Aluminum Columbia Falls	2,200	1,440
(1) Louisiana-Pacific (particleboard) Missoula	Neg	92
(1) Evans Products (plywood) Missoula	24	37
W. R. Grace Libby	700	4.5
(1) Champion-Hoerner Waldorf Missoula	365	760
Plum Creek Lumber Columbia Falls	65	34
St. Regis Paper Libby	277	696
(1) Champion-U. S. Plywood Bonner	224	288
Area Sources*		
Unpaved Roads	---	158,386
Agriculture	---	245
Open Burning	---	13,623
Other	3,282	3,221

(1) Western Corridor Sources

*For the counties of Flathead, Lake and Missoula

Source: Gelhaus et al. (1978)

point sources in the area. Other area sources (e.g., automobile traffic, wood-burning stoves, etc.) also contribute, on a smaller scale, to air pollutant concentrations. No other documented major emission sources are present in or near the remainder of the western corridors, and the lower population density makes area sources less of a problem than in the Missoula valley.

2. Northern Corridors

The Northern Corridor section describes the air quality and related parameters along the "hi-line" route. Beginning at Ovando in western Montana, the corridor passes through Great Falls, Havre, and Scobey, and leaves the state near Plentywood (see Figure 23). An alternate "hi-line" route from Havre through Glasgow was deleted by DNRC.

a. PSD Class I Areas

Three PSD Class I areas are within 48 km (30 miles) of the "hi-line" pipeline alternate route. They are the Bob Marshall/ Scapegoat Wilderness, north of the Ovando-Lincoln area; Gates of the Mountains Wilderness, south of Great Falls; and Medicine Lake National Wildlife Refuge, in northeastern Montana (as shown in Figure 25). Potential emissions near these areas will be subjected to PSD Class I restrictions.

b. Ambient Air Quality

Great Falls is the only metropolitan area along the northern corridor and is the only area with a significant amount of air quality data (Figure 23). Scobey, in northeastern Montana, has a limited data record. The remainder of the northern corridor is not monitored by the AQB and is believed to have an overall air quality cleaner than national or state standards.

Sampling in the Great Falls area indicates violations of federal primary and state TSP standards and the state sulfation rate standard. The Great Falls central business district has been designated non-attainment for TSP. During 1977, particulate concentrations reached a maximum 24-hour level of 869 $\mu g/m^3$; the annual geometric mean was 52.4 $\mu g/m^3$. Maximum sulfation rate values were recorded near an oil refinery with a peak value of 0.63 milligrams sulfur trioxide per 100 square centimeters per day ($mgSO_3/100\ cm^2/day$).[4] Table 9 shows the levels of pollutants measured in Great Falls during 1977.

In the Scobey area, three air quality stations were established by the AQB to determine background pollutant levels prior to the construction of a Canadian power plant. Annual geometric means for TSP at the stations ranged between 20 and 25 $\mu g/m^3$ during 1977.[5] Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) data collected at Scobey had concentrations very near zero.

Glasgow, which lies south of the alternate corridor, has both AQB data and data from a MERDI study of the air force base. This information was not included because of its distance from the pipeline alternate corridor, but data summaries indicate pollutant concentrations are well below state or federal standards.

With the exception of the downtown Great Falls area, no air quality problems are evident along the northern "hi-line" corridor.

c. Emission Sources

The only documented major point sources along the corridor are in the Great Falls area. Table 11 outlines estimated pollutant emissions from two grain processing plants and from a local oil refinery. Depending upon population density

Table 11.--Great Falls Area Estimated Emissions - 1977

Sources	Estimated Emissions Sulfur Dioxide	(Tons Per Year) Particulates
Point Sources		
(1) Con-Agra - Great Falls	0	70
(1) General Mills - Great Falls	0	32
(1) Phillips Petroleum - Great Falls	1,807	72
Westco Refining - Cut Bank	883	11
Area Sources	2,600	251,000

Source: Gelhaus *et al.* (1978)

(1) Northern Corridor Sources

and/or land use, area sources (including motor vehicles and agricultural activities, etc.) may contribute to background pollutant levels. Since the majority of the northern route traverses sparsely populated regions, normal urban pollutants should be minimal.

3. Central Corridors

Much of the Northern Tier Pipeline Company's proposed route is contained within the central corridor. One corridor starts at Avon and passes through Helena, Townsend, Harlowton, Mosby, and Fairview. An alternate corridor runs eastward from Great Falls to Mosby. Figure 23 outlines the routes covered in this portion of the report.

a. PSD Class I Areas

Several PSD Class I areas may affect the potential for impact on air quality along the central routes. Northeast of Helena lies the Gates of the Mountains Wilderness (Figure 25), a PSD Class I area. The U. L. Bend National Wildlife Refuge and the Medicine Lake National Wildlife Refuge are other PSD Class I areas within 48 km (30 miles) of the central corridor.

b. Ambient Air Quality

As in other areas of the state, air quality varies widely along the central corridors. Pollutant levels are monitored only at Helena and Circle (Figure 23) by the AQB. Air quality within and adjacent to the central corridor generally is considered good, with the exception of the area surrounding a lead smelter near Helena.

Portions of the Helena valley have been designated non-attainment for TSP and SO_2. An industrial slag dump and contaminated soil in the East Helena area are the basis for the

TSP non-attainment designation in a small downtown area north of the lead smelting operation. A 0.67 km radius area surrounding the lead smelter also has received a non-attainment rating for SO_2, based on monitoring data and modeling. Sampling performed in the area for SO_2 and TSP has shown violations of state and federal standards. In East Helena, TSP reached a maximum 24-hour value of 192 $\mu g/m^3$, with an annual geometric mean of 66.7 $\mu g/m^3$. Sulfur dioxide, at sites south of the lead smelter, has reached maximum 24-hour concentrations between 0.16 and 0.26 ppm. Table 9 shows a summary of selected ambient air quality data for the East Helena area.

Data collected at Lindsay, near Circle, showed TSP levels of approximately 28 $\mu g/m^3$ annual geometric mean during 1977. These values are indicative of good air quality; however, future coal development may alter existing air quality.

In the absence of monitoring data, the remainder of the central corridors are considered to have good air quality. Further substantiation is furnished by the lack of population centers or industrial sources.

c. Emission Sources

Few documented major emission sources are present along the corridor, but in the Helena area the lead smelter is the primary source. Table 12 shows estimated emissions along the central route. Currently, the smelter is on a compliance program to control both particulate matter and SO_2 from the sintering operations.[4] Other point sources include a cement plant in Montana City (south of Helena) and a small lumber mill in Townsend.

Table 12.--Helena-Butte Area Estimated Emissions - 1977

Sources	Estimated Emissions Sulfur Dioxide	(Tons Per Year) Particulates
(1) ASARCO - East Helena	14,500	418
(2) Anaconda Company - Anaconda	281,750	4,780
(1) Kaiser Cement - Montana City	---*	204
(2) Ideal Cement	---	263
Pfizer - Dillon	5	124
(2) Berkeley Open Pit Mine - Butte	207	4,023
(2) Stauffer Chemical Co. - Silver Bow	208	73
U. S. Plywood - Silver City	1	13
(1) Townsend Lumber - Townsend	1	20
(2) Yellowstone Pine - Belgrade	1	15
Elks Studs - West Yellowstone	1	12
(2) Burkland Studs - Livingston	1	12
Area Sources+		
Unpaved Roads	---	81,278
Agriculture	---	101
Open Burning	---	7,047
Other	977	2,816

*Unknown
+Only the counties of Lewis & Clark, Deer Lodge, and Silver Bow
(1) Central Corridor Sources
(2) Southern Corridor Sources

Source: Gelhaus et al. (1978)

With the exception of the Helena valley, population related area sources (e.g., motor vehicle emissions) can be expected to be minimal. Other area sources will vary depending on agricultural practices, land use, unpaved roads, etc.

4. Southern Corridor

The southern corridor also is called the "interstate" route, since it follows I-90 through most of the state (see Figure 23). Starting at Garrison (west of Deer Lodge), the alternate corridor passes through Anaconda, Butte, Bozeman, Billings, Miles City, Glendive, and Sidney before leaving Montana. A short, alternate segment bypasses the Butte-Anaconda area by connecting Deer Lodge with Bozeman or with the central corridor (see Figure 23).

a. PSD Class I Areas

The Anaconda-Pintlar Wilderness area is the only PSD Class I area within 48 km (30 miles) of the southern alternate corridor. Figure 25 shows its location southwest of Anaconda. Yellowstone National Park and the Northern Cheyenne Indian Reservation fall within 96 km (60 miles), but both Class I areas are expected to experience minimal impact from the southern route.

b. Ambient Air Quality

Numerous locations along the southern route have air quality monitoring data (see Figure 23). Butte, Anaconda, Bozeman, Billings-Laurel, Miles City, and Glendive have AQB monitoring sites.

Sampling for sulfur dioxide and particulate matter in the Anaconda area shows violations of federal and state sulfur dioxide standards, and of federal particulate standards. A

non-attainment designation for SO_2 has been given to the area surrounding Anaconda and to the area south and west of the copper smelter operations. Maximum 1-hour and 3-hour SO_2 concentrations measured at monitoring sites were 3.51 ppm and 2.87 ppm, respectively.[5] Annual arithmetic averages ranged between 0.023 and 0.038 ppm. Table 9 summarizes selected air quality data for the Anaconda area. During 1977, particulate measurements resulted in one 24-hour sample exceeding federal secondary standards (150 $\mu g/m^3$), but primary standards were not exceeded.

Particulate concentrations in Butte frequently reach levels exceeding federal and state standards. In Butte, the open-pit mining operation and adjacent areas to the south and east have been designated non-attainment for TSP. Two monitoring sites near the open pit mine had annual geometric means of 78.7 and 65.4 $\mu g/m^3$.[5] The Butte-Anaconda area is the subject of a proposed plan to upgrade the air quality to comply with ambient air quality standards through 1985.[4]

Limited particulate data have been collected in the Bozeman area (at Montana State University); particulate concentrations are low, but may not be representative because they are collected in the center of the university campus. Although the Bozeman area has no major industrial sources, future population growth may increase area sources and degrade existing air quality.

One of the largest metropolitan areas in Montana, the Billings-Laurel area, has a number of air quality problems. Downtown Billings has been designated non-attainment for CO and TSP. Furthermore, the area around the oil refinery in Laurel (2.0 km radius) is a non-attainment area for SO_2. Table 9 summarizes selected air quality data for the Billings

area. Federal secondary particulate standards were violated by a maximum 24-hour value of 165 $\mu g/m^3$ recorded at the City Hall site.[5] Carbon monoxide levels, with a maximum 8-hour concentration of 13.1 ppm, exceeded the federal 8-hour standard. Ozone (O_3) and nitrogen dioxide (NO_2) levels measured in the area were within air quality standards. Sulfur dioxide measurements during 1977 indicated concentrations in excess of state and federal standards at one or more monitoring sites, but SO_2 levels in Billings (Table 9) were less than those recorded in Laurel. Maximum 1-hour, 3-hour, and 24-hour concentrations of 0.63, 0.45, and 0.25 ppm, respectively, were recorded around the Laurel refinery.[4] The Billings area is the subject of an Air Quality Maintenance Plan for reducing particulate and SO_2 levels to within the ambient standards through 1985.

Miles City and Glendive are the final two locations on the southern corridor with AQB monitoring sites. Particulate data collected in both areas show relatively clean air, with annual geometric means of 15.5 $\mu g/m^3$ at Miles City and 19.09 $\mu g/m^3$ at Glendive.[5] No air quality problems are documented in this area.

In summary, the southern route has more air quality problem areas than other alternative and proposed routes.

c. Emission Sources

Numerous documented emission sources affect the ambient air quality of the southern corridor. In the Anaconda-Butte region, mining and smelting operations have major effects on ambient air quality. Large amounts of SO_2 and particulates are emitted from a copper smelter in Anaconda. Table 12 lists major emission sources along the route and their estimated particulate and SO_2 emissions for 1977. Butte's air quality

is significantly affected by the open-pit mining operation. Ore handling and heavy duty vehicle traffic emit large quantities of particulates and smaller amounts of SO_2, hydrocarbons (HC), and oxides of nitrogen (NO_x).[5] Between Butte and Anaconda, an elemental phosphorus plant emits significant quantities of fluorides, and lesser amounts of SO_2, and particulates. Other sources in the Butte area include a tepee burner, three hot mix plants, and a concentrator and crusher that process ore from the mine.

A cement plant near Three Forks also contributes to particulate levels along the corridor. Two small lumber processing plants in Belgrade and Livingston (Table 11) contribute small amounts of SO_2 and particulates to these regions. However, no significant air quality problems result from point sources between Three Forks and Laurel.

Numerous industrial sources contribute to the air quality problem in the Billings-Laurel area (see Table 12). Three oil refineries, a sugar processing plant, a coal-fired power plant, and a sulfur and chemical processing plant all emit pollutants in the region. Because of the large population of Billings, area sources (e.g., automobiles, fugitive dust, etc.) also may contribute significantly to air pollutant levels.

Other documented sources along the southern route include a coal-fired plant and sugar processing plant in Sidney. Table 13 lists emissions from these facilities. No other major emission sources have been documented by the AQB; however, small point and area sources do contribute to pollutant levels. The significance of these sources depends upon population density, land use practices, etc. along the corridor.

Table 13.--Billings Area Estimated Emissions - 1977

Sources	Estimated Emissions Sulfur Dioxide	(Tons Per Year) Particulate
Point Sources		
(1) Cenex - Laurel	10,380	398
(1) Conoco - Billings	3,198	263
(1) Exxon - Billings	9,800	932
(1) Great Western Sugar Co. - Billings	815	65
(1) Montana Power Company - Billings	9,986	1,124
(1) Montana Sulphur & Chemical Co. - Billings	1,530	Neg
U. S. Gypsum - Lewistown	Neg	73
Westmoreland - Hardin	---	19
Area Sources*		
Unpaved Roads	---	141,786
Agriculture	---	5,839
Open Burning	---	1,125
Other	2,007	3,662

*Only the counties of Yellowstone, Carbon, Stillwater, Sweetgrass and Big Horn

Source: Gelhaus *et al*. (1978)

(1) Southern Corridor Sources

Table 14.--Eastern Montana Estimated Emissions - 1977

Sources	Estimated Emissions Sulfur Dioxide	(Tons Per Year) Particulates
(1)Holly Sugar Company - Sidney	226	116
Montana Power Co. Unit #1 & #2 - Colstrip	5,326	618
(1)Montana-Dakota Utilities - Sidney	2,372	430
Tumpane Co. - Glasgow AFB	174	29
Area Sources*		
Unpaved Roads	---	81,170
Agriculture	---	4,068
Open Burning	---	803
Other	596	1,427

*Only the counties of Rosebud, Treasure, Custer, Fallon, Powder River and Carter

(1) Southern Corridon Sources

Source: Gelhaus et al. (1978)

IV. ASSESSMENT OF POTENTIAL IMPACTS

Construction and operation of the pipeline system may have minor impacts, both long-term and short-term, on climate along the pipeline corridors. The anticipated impacts on the climate should be localized and hardly detectable; however, a discussion of climatic impacts caused by large urban areas is included in Section IV.A.1 below. Of greater concern are the possible impacts that climate may have on the construction and operation of the pipeline, as well as climatic features which may affect the dispersal of pollutants that these activities will produce.

No major air quality impacts are expected to result from the Northern Tier pipeline in Montana; however, localized, minor impacts may be noted during construction and operation. Construction of the pipeline, pump stations, and transfer facilities could result in temporary emissions from equipment and in fugitive dust generation. Operation of the crude oil transportation system may result in some hydrocarbon and other emissions from pump stations and transfer facilities. Secondary impacts associated with the pipeline operation could include increased refinery production in Billings and Great Falls with possible subsequent deterioration of air quality in these areas.

A. Climate

The impact of potential emissions on the ambient environment will be determined to a large degree by the climatic conditions--specifically, the dispersion potential of the area. Climatic conditions also may affect pipeline construction and operations significantly.

1. Impacts of Pipeline Activities on Climate

The relatively low emissions expected from this project, when compared to impacts associated with large urban areas,

should minimally impact the climate of the area. Several impacts of aerosol emissions on climate in large urban areas have been identified and documented; these impacts are discussed in the following sections.

a. Impact of Emissions on Temperature

Aerosols can affect temperature characteristics of the atmosphere because of their effects on incoming and outgoing radiation. Gray, et al.[6] documented that large amounts of carbon black dust can effectively reduce the earth's albedo, resulting in a temperature increase. Ackerman, et al. presented evidence that large increases in aerosol concentrations can increase the infrared cooling of the aerosol layer.[7] Aerosols also can affect the vertical temperature structure of the atmosphere.[8] This may be important for pollution dispersion, if aerosol concentration increases are very large.

Some carbon black dust, or "soot", will be generated by diesel equipment used for pipeline construction. Other aerosols will be generated by pipeline activities; however, overall emissions are expected to be minor, and the effects of these emissions on temperature are expected to be negligible.

b. Impacts of Emissions on Precipitation

Studies on the effects of large urban areas on local precipitation patterns have produced interesting results. Auer[9] found that convective cumulus formation was favored over industrial pollution sources, and that increased precipitation occurred southeast of the St. Louis urban area. Changnon[10] found that 1) the urban heat island effect contributed to more cloud formation and higher

cloud bases, and 2) the presence of more giant nuclei enhanced cloud droplet coalescence. Aerosols produced by possible increased refinery activity in Billings and Great Falls could affect precipitation patterns through increased cloud condensation nuclei (CCN) formation; however, any change in precipitation patterns caused by slight increase in aerosols should be negligible.

2. Impacts of Climate on Pipeline Activities

Climate may have significant impacts on both the construction and operation of the pipeline and also is important in determining the severity of air quality impacts associated with this project.

During the construction phase, climate may have an adverse impact on the performance of outside work during winter months. Montana is subject to very cold temperatures during the winter, which can result in severe working conditions. Also of concern during construction are the high winds prevalent in central Montana and to a lesser degree in eastern Montana; these conditions could produce difficult working conditions and an increase in fugitive dust in the vicinity of pipeline construction activities.

Climatic impacts also will occur during the operational phase. During periods of extreme cold, additional stress may be put on people, materials, and machinery needed for pipeline operation. High winds or icing may down power lines, resulting in a curtailment of operations. Heavy thunderstorms may contribute to a break in the pipeline by causing flash flooding at stream crossings; mudslides also could be disastrous if the pipe were not properly constructed and sited. In addition, frost during the winter months can buckle ground within the frost zone, which could be a problem if the pipeline were not built to withstand these stresses.

A major siting consideration associated with this project is the relationship of the climate to air quality impacts. In

areas of poor dispersion potential and complex topography, relatively minor emissions may cause air quality problems, although air quality problems from the same emissions might be minimal in areas of good dispersion potential and open terrain. In western Montana, the dispersion potential is poor, and there may be problems with pollutant buildups during construction--particularly in valleys with frequent temperature inversions. In central and (to a lesser degree) eastern Montana, higher wind speeds and less frequent inversions will cause pollutants to disperse more readily. During the construction phase, however, much excavation will occur, and high winds may increase the particulate concentrations and reduce visibility by causing dust entrainment.

B. Air Quality

As it passes through Montana, the Northern Tier pipeline will impact the air environment during two phases--construction and operation. Some of the potential air quality impacts resulting from assembly and use of the pipeline in transporting crude oil from the west coast to the midwestern United States are discussed in the following sections.

1. Pipeline Construction

Construction of the Northern Tier pipeline will be performed over an eight- to twelve-month period; a majority of the work will be accomplished during the months of April through November.[11] To aid in identifying potential air quality impacts, the following chronological list of construction activities is presented:

- Clearing and grading right-of-way;
- Hauling and stringing line pipe;
- Trenching;
- Pipe bending, laying, and welding;
- Protective coating;
- Lowering-in and tying-in;

- Backfilling;
- Special construction (e.g., water crossing, highway, and rail crossings); and
- Clean-up and restoration.

Numerous air pollutants will be produced during pipeline construction. Several pollutants, including nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), hydrocarbons (HC), and particulates will be emitted by construction equipment. Increased fugitive dust levels occurring along the pipeline route may reduce visibility. In addition, open-burning of debris and construction work camps activities may increase air pollutant levels. Audio noise levels in the vicinity of the pipeline may increase during construction activities when heavy equipment is operating. Electromagnetic interferences in the immediate area may result from equipment ignition systems and other electrical apparatus.

Air pollutant emissions from construction equipment exhaust would consist mainly of NO_x and CO, with smaller quantities of SO_x, hydrocarbon, and particulates. According to the Federal Power Commission's EIS on the Alaskan Natural Gas Pipeline[12], NO_x would be emitted at a rate of about 400 to 500 pounds per 1,000 gallons of fuel consumed. Carbon monoxide would be emitted at about one-fifth this rate and the other pollutants at less than one-tenth of the NO_x rate. Welding and field coating of the pipe sections also will contribute to air emissions. Table 15, from the federal draft environmental impact statement for the Northern Tier pipeline, estimates pollutant emissions from pipeline construction.

Dust emissions resulting from pipeline construction and related activities may create potential problems at construction sites, stockpiling areas, unpaved haul roads, quarries, and construction work camps. The quantities of dust produced will be a function of soil and meteorological conditions. According to the U.S. Department

Table 15.--Pollutant Emissions from Pipeline Construction

Pollutant	Emission Rate (lb/working day)
Nitrogen oxides	4,400
Carbon monoxide	1,400
Hydrocarbons	310
Sulfur dioxide	290
Particulates	190
Fugitive dust	7,700-11,000

Source: Science Applications, Incorporated, 1978, through the U.S. Department of the Interior, 1979.

of the Interior[13], dust emissions from pipeline construction are roughly equivalent to emissions arising from highway construction operations; based on this assumption, an estimated dust emission rate of five tons per pipeline mile was derived.* This agrees with the values in Table 15, using one pipeline mile per working day. The impact of fugitive dust on the area surrounding the construction site will be a function of the meteorological conditions of the area, as will the buildup of other pollutants (e.g., NO_x, CO, etc.).

Disposal of debris (e.g., trees, brush, etc.) from clearing the right-of-way could be accomplished by open burning. Low flame temperatures associated with open burning produce particulates, CO, and hydrocarbons and lesser amounts of NO_x and SO_x.[12] Temporary degradation of air quality and annoyance of nearby residents may result from this method of debris disposal. However, open burning will probably be limited to non-urban areas and should affect relatively few people.

Construction work camps, if required, could be another source of air pollution; fuel burning for heat, and waste incineration are two possible sources. If nearby towns or cities absorb short-term population increases associated with construction, minor increases in area emission sources are possible. However, these effects are short-lived and should not cause any significant deterioration of air quality.

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* FDE = (EF)(W)(T)/43,560
= (1.12)(40)(1)(5280)/43,560
= 5.4 tons per pipeline-mile.

FDE = Fugitive dust emission (tons/mile)
EF = Emission factor (1.12 tons dust/acre/month)
W = Width of excavated right-of-way (40 feet)
T = Time of operation (1 month).

2. Construction of Pump Stations and Transfer/Delivery Facilities

Air pollutants generated during construction of pump stations and transfer facilities should be similar to those discussed in the previous section on pipeline construction. Emissions from the construction of typical pump stations and pressure reducing stations, based on EPA emission factors, are given in Table 16. Disturbance of six or seven acres per site will result in some fugitive dust emissions with possible deterioration of visibility until the area is reclaimed.[14] Impacts generally will be very localized, depending on soil and meteorological conditions.

Transfer and delivery facilities will be constructed at intersections with the Glacier and Western Crude Oil Pipelines in Montana. Quantities of pollutants generated during the construction of the facilities are expected to approximate the on-shore storage facility construction emissions.[14] However, differences in climatic conditions between the west coast and Montana may make these estimates of dust generation low.

3. Pipeline Operation

Crude oil pipelines cause very little impact on air quality during normal operation; however, accidents, such as spills, fires, etc., could cause significant emissions. The impacts of these emissions will vary with location.

Seven pump stations are scheduled for installation on the Northern Tier pipeline route in Montana. Since their primary power source is electrical motors, no emissions are expected. However, back-up diesel-powered generators will emit minor amounts of pollutants (e.g., NO_x, CO, etc.) when operating. As shown in Table 17, emissions from generators should be minimal; in addition, short periods of operation (only for lubrication and for back-up power when required) should not contribute to the buildup of air pollutants.

Table 16.--Pollutant Emissions from Construction of a Typical Pump Station

Pollutant	Emission Rate (lb/working day)
Nitrogen oxides	660
Carbon monoxide	160
Hydrocarbons	46
Sulfur dioxide	46
Particulates	27
Fugitive dust	500

Source: Science Applications, Incorporated, 1978, through U.S. Department of Interior, 1979.

Table 17.--Diesel Back-up Generator Emissions

Pollutant	Emission Factor (lb/1000 gal)*	Emission Rate** lb/hr.	lb/week
Carbon Monoxide	102	0.816	0.816
Exhaust Hydrocarbons	37.5	0.300	0.300
Nitrogen Oxides	469	3.75	3.75
Aldehydes	7.04	0.056	0.056
Sulfur Oxides	31.2	0.250	0.250
Particulates	33.5	0.270	0.270

* Emission factors are from AP-42, Compilation of Air Pollutant Emission Factors, Environmental Protection Agency, February 1976.

** Emission rates are based upon 8 gallons fuel consumption per hour and 1 hour operation time per week (for lubrication purposes).

Surge tanks, if installed, have the potential for hydrocarbon emissions, as do fixtures in the pumping train (e.g., valves, flanges, pump seals). However, hydrocarbon emissions near the proposed facilities should not exceed the federal guidelines[14] and ordinarily would be negligible. Delivery/ transfer facilities, such as the proposed Glacier and Western Crude Oil facilities in Montana, may release hydrocarbon from storage tanks. Table 18 lists emissions from the Montana transfer stations. Noise levels in the vicinity of the pump stations and transfer facilities will be increased. Furthermore, electromagnetic interferences with radio and/or television reception may be caused by the electrically driven pump stations, transfer facilities, and associated high-voltage power lines.

Table 18.--Hydrocarbon Emissions, Transfer Facilities

Transfer Facility	Annual Emission Rate (Tons/Year)	Worst-Case Emission Rate (lb/hr)
Glacier	25.4	9.4
Western Crude	18.3	7.2

Source: Science Applications, Incorporated, 1978 through U.S. Department of Interior, 1979.

V. SHORT-TERM AND LONG-TERM IMPACTS

Pipeline impacts on air quality and climate can be separated into short-term and long-term impacts. Construction impacts generally are short-term, whereas operational impacts can be considered long-term. Construction emissions, such as heavy equipment exhaust, fugitive dust, smoke from open burning, welding and pipe coating emissions, etc., should have short-term impacts on air quality in a localized area. The degree of impact will be strongly influenced by the local atmospheric dispersion potential. Accidents, such as oil spills, fires, etc. also should produce only a short-term impact on the air environment.

Operational (long-term) impacts include hydrocarbon emissions from pump station surge tanks and from storage tanks at delivery facilities. Diesel back-up generators at pump stations also will emit small quantities of pollutants (e.g., NO_x, CO, etc.) when in periodic or emergency operation. Although minimal, emissions from maintenance vehicles and dust from roads also will contribute to long-term impacts. A possible increase in refinery production in Billings and Great Falls, because of the additional crude oil supply from the pipeline, could have secondary long-term impacts on air quality and, to a lesser degree, climate. The soil microclimate surrounding the pipe also may be affected by the higher temperature of the crude oil. However, the Northern Tier Pipeline should not affect the long-term preservation of the existing air quality or climate in Montana significantly, if prudent construction, reclamation and operating guidelines are followed.

VI. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS

The air environment is essentially a renewable resource when not subjected to continuous pollution. Although emissions from pump stations and delivery facilities could be considered irreversible during operation, abandonment of the pipeline should reverse these impacts. Therefore, no irreversible or irretrievable commitments of air quality or climate along the pipeline route are anticipated.[14]

VII. MITIGATING MEASURES

Numerous mitigating measures can be applied to help reduce construction impacts on ambient air quality:

- Proper fuel system adjustment, regular maintenance, use of specified fuels, and good operating techniques can be employed to reduce air pollutant emissions from construction equipment.
- Using factory coated pipe will help reduce emissions produced by application of the pipe's protective cover in the field.
- Fugitive dust emissions can be reduced by 30 percent to 70 percent depending on the extent of surface use[15] by watering unpaved surfaces used during construction activities.
- Dust generated during blasting operations can be reduced by spraying water or water with chemical wetting agents over the blast area.
- Operations should be restricted during extremely windy periods when excavated top soil may be disturbed.
- Re-establishing vegetative cover on the pipeline corridor as soon as possible after construction will aid in reducing wind blown dust; this is important because fugitive dust is expected to be the most significant construction impact.
- Overall, good quality control and supervision will be important in reducing impacts on air quality during pipeline construction.

Mitigating measures can be used to reduce operational impacts associated with pump stations and transfer facilities:

- Hydrocarbon emissions from crude oil surge/relief and storage tanks can be controlled by floating roofs or internal floating covers and vapor recovery units. Floating roofs can reduce vapor losses approximately 80 percent compared to a fixed roof tank. Installation of a vapor recovery unit, though expensive, can reduce emissions from a fixed roof tank by as much as 95 percent.[15] According to Butler Associates, Incorporated,[16] (Northern Tier pipeline engineers), a floating roof will be used on relief tanks.

- Proper fuel system adjustment, regular maintenance, use of specified fuels, and good operating practices can be used to reduce emissions from diesel back-up generators at pump stations.

- A quick-response program for handling emergencies (i.e., spills, fires, etc.) will be important in reducing possible air pollutant emissions.
- Use of the best available control technology for the pumping stations and transfer facilities will assure minimal emissions.

VIII. SIGNIFICANCE OF IMPACTS ON RESOURCE

The significance of impacts on air quality associated with the pipeline is dependent upon both the types and amounts of pollutants emitted and the dispersion potential of the area in question.

In western Montana, the dispersion potential is generally poor, so that emissions may become trapped in valleys during inversion conditions. In central Montana, the dispersion potential is very good; normally, concentrations of pollutants should remain low. However, windy periods during construction may result in an increase of fugitive dust. This also is true in eastern Montana, but to a lesser degree. Emissions should be so minor that any deterioration in air quality will be undetectable except for short-term, localized conditions during construction.

Secondary air quality impacts may occur in Great Falls and Billings because of increased refinery production; the significance of these impacts is unknown at this time. The overall potential impact of the Northern Tier pipeline on climate and air quality in Montana appears insignificant when compared to other resources (e.g., biological, water quality, etc.).

IX. GROWTH INDUCING OR INHIBITING IMPACTS

Because the Northern Tier pipeline may foster population growth through accomodation of the construction work force and through possible increases in refinery production (Billings and Great Falls), some air quality deterioration may occur. Increased population may lead to rises in area air pollutant emissions. The degree of impact is a function of the area's ability to absorb increases in population and air emissions.

However, industrial growth in certain areas may be inhibited by the Northern Tier pipeline. Prevention of Significant Deterioration (PSD) regulations limit by class (I, II, or III) the incremental amount of pollutants that can be added to baseline levels; PSD increments have been established only for particulates and sulfur dioxide, but other criteria pollutants are scheduled for future PSD regulation by the Environmental Protection Agency (EPA). By depleting part of the PSD increments, the Northern Tier pipeline could restrict the future industrial development in certain areas. The pipeline emissions during operation may be insignificant enough to have minimal effect on PSD Class I or II increments.

X. RECOMMENDATIONS FOR LONG-TERM MONITORING

If pump stations and transfer facilities appear to have significant effects on local air quality, a monitoring program should be established. Air quality/meteorological monitoring stations would be sited near the pump and transfer facilities to define the air quality impacts of pipeline operation. In addition, audio and electromagnetic levels should be measured to define operational impact.

XI. CONSTRUCTION GUIDELINES

The following practices should be followed to reduce air quality impacts during construction:

- Proper fuel system adjustment, regular maintenance, use of specified fuels, and good operating techniques can be employed to reduce air pollutant emissions from construction equipment.
- Using factory coated pipe will help reduce emissions produced by application of the pipe's protective cover in the field.
- Fugitive dust emissions can be reduced by 30 percent to 70 percent, depending on the extent of surface use[15] by watering unpaved surfaces used during construction activities.
- Dust generated during blasting operations can be reduced by spraying water or water with chemical wetting agents over the blast area.
- Operations should be restricted during extremely windy periods when excavated top soil may be disturbed.
- Re-establishing vegetative cover on the pipeline corridor as soon as possible after construction will aid in reducing wind blown dust; this is important because fugitive dust is expected to be the most significant construction impact.
- Overall, good quality control and supervision will be important in reducing impacts on air quality during pipeline construction.
- Burning of slash and other debris should be limited only to unpopulated areas and should be performed only during periods of favorable dispersion conditions.
- Effective noise attenuation practices should be used where appropriate.

XII. SUMMARY OF RATINGS FOR PROPOSED AND ALTERNATE CORRIDORS

The first step in compiling the air quality and dispersion potential ratings was to define five principal routes--designated as the Northern Tier Proposed Corridor (via Helena/Mosby), the Northern Alternate Corridor (via Great Falls/Scobey), the Central Alternate Corridor (via Great Falls/ Mosby), the Southern Alternate Corridor (via Boulder/Harlowton), and the Interstate Alternate Corridor (via Butte/Sidney). It was found that the intra-route alternatives did not affect the overall meteorology or air quality ratings.

The summaries, shown in Table 19,give the number of kilometers along each route that were rated as good, fair, and poor for dispersion potential and existing air quality. The overall ratings in Table 19 were calculated as shown in the following example for the Northern Tier Proposed Corridor.

1. <u>Air Quality</u>

$$\frac{513}{651} \times (1) \times (100) = 78.8$$

$$\frac{116}{651} \times (2) \times (100) = 35.6$$

$$\frac{22}{651} \times (3) \times (100) = 10.2$$

<u>Dispersion Potential</u>

$$\frac{120}{651} \times (1) \times (100) = 18.4$$

$$\frac{306}{651} \times (2) \times (100) = 94.0$$

$$\frac{225}{651} \times (3) \times (100) = 103.8$$

Total 340.8

In step #1 each of the mileage percentages were multiplied by the appropriate weighting factors (using good = 1, fair = 2, poor = 3) and summed.

2. $\frac{340.8}{12} \times \frac{(651)^*}{(651)} = 28.4$

*Note that this distance is the actual total route mileage being considered, in this case the Northern Tier Proposed Route.

The result from step #1 then was divided by the sum total of weighting factors for both air quality and dispersion potential (1+2+3+1+2+3=12) and adjusted according to the total route mileage using the Northern Tier Proposed Route as the basis for comparison (651 miles). The distance adjustment was made because, given the same existing air quality and dispersion potential, a shorter route would be more favorable than a longer route. The overall rating obtained in step #2 will be between 16.6 (all criteria rated good) and 50.0 (all criteria rated poor).

From these results, it was concluded that air quality and dispersion potential along the Northern Tier Proposed Route does not differ significantly from that of three DNRC alternatives. The interstate alternate, however, was rated significantly worse, as indicated by its overall rating of 32.8. This supports DNRC's deletion of this route from further consideration as an alternative.

Figures 26 and 27 illustrate the air quality and dispersion potential ratings assigned to the Northern Tier Proposed Corridor and alternates in Montana.

Table 19.--Centerline Rating Summary of Proposed and Alternate Corridors

		Air Quality Ratings in Kilometers (Miles)				Dispersion Potential Ratings in Kilometers (Miles)		
	Overall Rating*	Good	Fair	Poor	Total Distance	Good	Fair	Poor
Northern Tier Proposed Corridor	28.4	826 (513)	187 (116)	35 (22)	1048 (651)	193 (120)	493 (306)	362 (225)
Central Alternate N.T. #1	28.2	802 (498)	219 (136)	35 (22)	1056 (656)	230 (143)	509 (316)	317 (197)
Southern Alternate N.T. #2	27.2	955 (593)	71 (44)	35 (22)	1060 (659)	225 (140)	463 (288)	372 (231)
Northern Corridor (Hi-Line)	26.2	713 (443)	250 (155)	35 (22)	998 (620)	335 (208)	346 (215)	317 (197)
Interstate Corridor**	32.8	978 (608)	145 (90)	92 (57)	1215 (755)	298 (185)	470 (292)	447 (278)

*Possible range for Northern Tier Proposed Route:
16.6 (all criteria rated good)
50.0 (all criteria rated poor)
**Centerline not established--distances estimated from highway map.

Segments Included In Pipeline Corridors

1. Northern Tier Proposed Corridor:
   Segments: 1-25; 27-39; 41, 66, 68; 98-100; 81; 84-97.

2. Central Alternate Northern Tier #1:
   Segments: 1-25; 27-39; 40; 98-100; 81; 84-97.

3. South Alternate Northern Tier #2:
   Segments: 1-25; 26; 42-62; 63, 79, 80; 82-97.

4. North Corridor (Hi-Line):
   Segments: 1-25; 27-39; 40; 98-106.

5. Interstate Corridor (Southern):
   Segments: None Provided.

Note: Other intra-route segments do not affect the overall rating of proposed and alternate corridors.

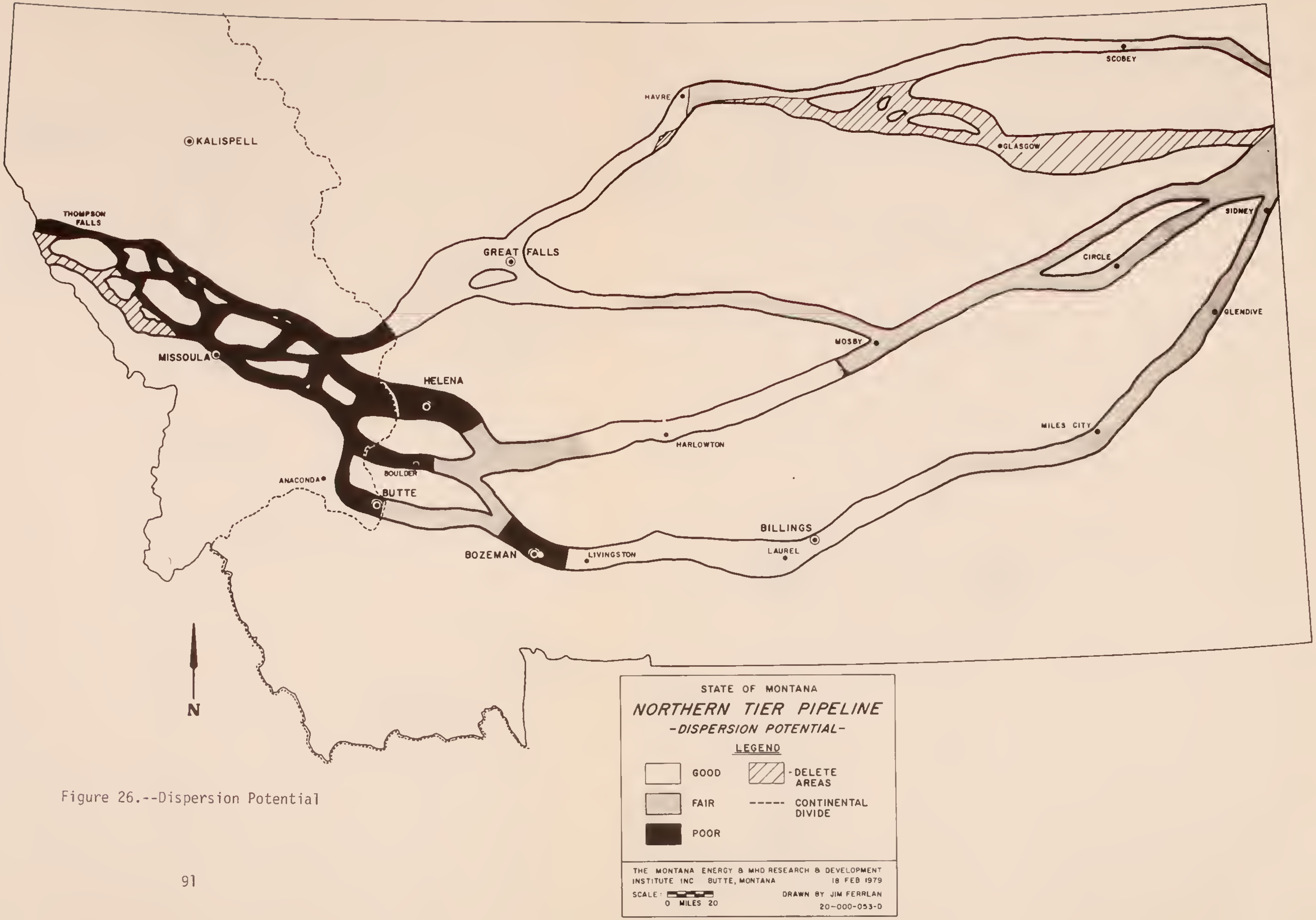

Figure 26.--Dispersion Potential

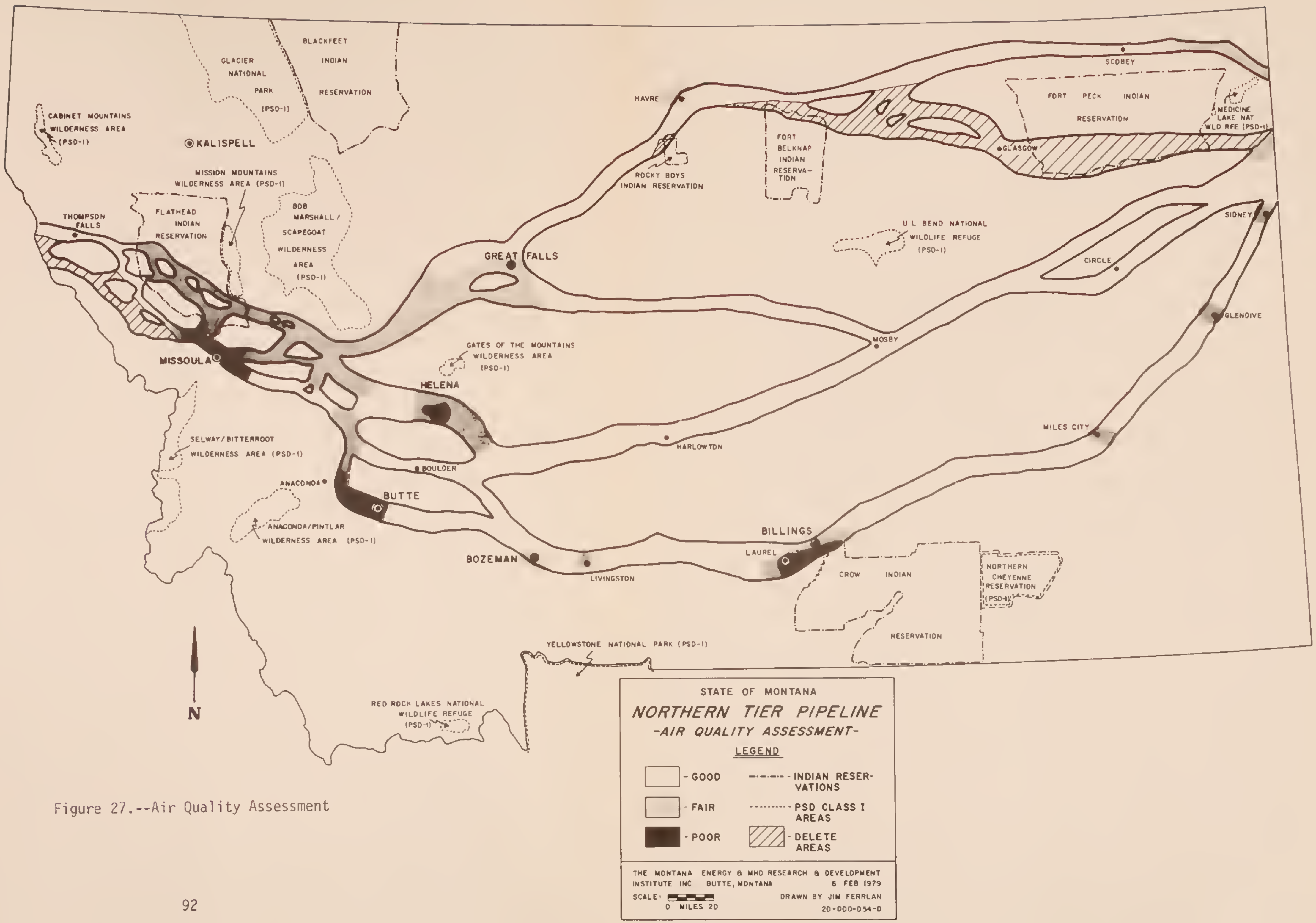

Figure 27.--Air Quality Assessment

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GLOSSARY

Aerosol--A suspension of fine, solid, or liquid particles in a gas (e.g., suspended dust particles in air).

Air Quality--A term related to the amount of designated air pollutants (e.g., particulates, SO_2, CO, etc.) in the ambient atmosphere, referenced to established standard(s).

Area Sources--Sources that emit air pollutants over an unspecified area (e.g., agricultural practices).

Atmospheric Stability--The tendency for a small parcel of air in the atmosphere, when displaced vertically, to have positive, neutral, or negative buoyancy as explained below:

a) Stable--Atmospheric stability exists if a small parcel of air in the atmosphere, when displaced upward, has negative buoyancy. This generally occurs when the temperature lapse rate is less than $10^{o}C/1000M$.

b) Neutral--Atmospheric Stability exists if a small parcel of air in the atmosphere, when displaced upward, has neutral buoyancy. This generally occurs when the temperature lapse rate is about equal to $10^{o}C/1000M$.

c) Unstable--Atmospheric stability exists if a small parcel of air in the atmosphere, when displaced upward, has positive buoyancy. This generally occurs when the temperature lapse rate is greater than $10^{o}C/1000M$.

Background Pollutant Levels--The concentrations of various pollutants already present in the ambient air at a specified time (e.g., prior to construction of an emission source).

Bimodal--Having two separate statistically frequent values, or modes.

Chinook--A strong warm wind, usually of westerly origin, which descends the eastern slopes of the Rocky Mountains during the winter months.

Coalescence--An atmospheric phenomenon in which several water droplets form around a common nuclei.

Continental Climate--A climate characteristic of the Great Plains states, marked by low and irregular precipitation and large temperature ranges.

Criteria Pollutants--Pollutants designated by the Environmental Protection Agency as having 1) adverse health or environmental effects either singly or in combination and 2) ambient air quality standards or guidelines that have been set. These presently include: particulates, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrocarbons, carbon monoxide (CO), and photochemical oxidants (ozone).

Dispersion Potential--The ability of the atmosphere to dilute released pollutants to lower concentrations.

Diurnal--Pertaining to a daily cycle such as diurnal temperature variations.

Fugitive Dust--Emissions related to natural or man-made dusts that become airborne due to the forces of wind, man's activity, or both.

Geometric Mean--A statistical average used to compute particulate concentrations; $g = (p_1 \times p_2 \ldots\ldots p_n)^{\frac{1}{n}}$ where g is the geometric mean, p is the pollutant concentration, and n is the number of individual concentrations used to compute that mean.

Growing Season--The period between the last occurrence of freezing temperatures in the spring and the first occurrence of freezing temperatures in the fall.

Inversion--An inversion exists when the temperature increases with increasing height in the atmosphere. An inversion layer in the lower atmosphere tends to trap pollutants, increasing their concentration.

Isopleth--A line on a map connecting points at which a given variable has a specified constant value (e.g., topographical map lines depict points of constant elevation).

Mixing Height--The vertical depth of the atmosphere through which neutral or unstable atmospheric stability exists, measured from the ground up (i.e., pollutants are mixed or dispersed within this layer).

National Ambient Air Quality Standards (NAAQS)--Rules established by the Environmental Protection Agency, that regulate the concentrations of criteria air pollutants in ambient (outside) air.

Non-Attainment Area--An area that exceeds national ambient air quality standards for one or more pollutants.

Pacific Coast Climate--A climate characteristic of the northwestern United States, marked by high annual precipitation and moderate temperature ranges.

Particulate Matter--Any material, except water, in uncombined form that is or has been airborne, and exists as a liquid or a solid at atmospheric conditions.

Percentage of Possible Sunshine--The ratio of the hours of sunshine to the total hours of daylight, expressed as a percentage.

Point Sources--Sources that emit air pollutants from a fixed location (e.g., power plant, oil refinery, etc.).

Prevention of Significant Deterioration (PSD)--Regulations established under the Clean Air Act Amendments that limit the amount of additional pollutants that can be added to baseline levels in areas where air quality is better than national standards.

Primary Standards--National ambient air quality standards designed to protect human health.

Quadrant--An arc of 90^{o} that is one quarter of a circle. The south-westerly quadrant, for example, refers to wind directions between 180^{o} and 270^{o}.

Relative Humidity--The ratio of atmospheric vapor pressure to saturation vapor pressure.

Secondary Standards--National ambient air quality standards designed to protect property, the environment, and other elements of the public welfare.

Sulfation Rate--The rate at which sulfur compounds are accumulated by a collection device (sulfation plate), giving a measure of the quantity of reactive sulfur compounds in the atmosphere.

Wind Chill Factor--The still air temperature that would have the same cooling effect on exposed human flesh as a given combination of temperature and wind speed.